The Living World Class 5 Notes Biology Chapter 1

1. Living World: Characteristics

The earth serves as a home for diverse living organisms. The organisms live in various habitats like forests, mountains, deserts, oceans, freshwater bodies, hot springs, polar regions and almost every place of the earth. Living things possess certain characteristics, which makes
Some of these important characteristics are shown in the flowchart given below:

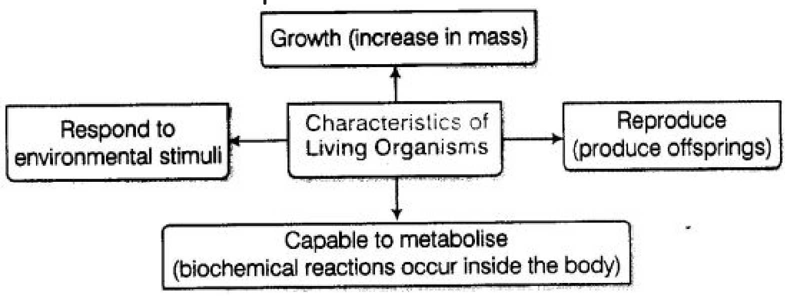

Fig. 1.1 Living organisms (an overview)

Major Characteristics of Living Organisms:

Major characteristics of living organisms are given below

1. Growth

Living things grow by increase in mass and increase in number of individuals/cells. In multi cellular organisms in particular, growth occur by cell division or increase in number of cells. Growth occurs continuously throughout life in plants, whereas, in animals, it occurs up to a certain age only. However, growing in certain body parts like nails, hair and replacement of lost cells, occurs throughout the life.
In unicellular organisms, growth can be observed under the microscope by simply counting the number of cells via in vitro experiment.

Non-living things like mountains, boulders, sand dunes also grow in size, but just by accumulating the material on their external surface. Thus, growth in living things is internal, while in non-living things, it is external. It is to be noted that a dead organism do not grow.

2. Reproduction

Reproduction, a characteristic of living organisms is the process of producing

offsprings, possessing features similar to those of parents. In multicellular organisms, the mode of reproduction is generally sexual. Living organisms also reproduce by asexual means.
Some examples are given below
(i) Fungi spread and multiply fast by producing millions of asexual spores. Some fungi, the filamentous algae and the protonema of mosses multiply by fragmentation.
(ii) In yeast and Hydra, budding occurs to produce new organisms. While, in Planaria (flatworm),
regeneration of fragmented body parts occur. These parts inturn grow as a new organism.
(iii) Unicellular organisms like bacteria, algae and Amoeba reproduce by increasing the number of cells, i.e., through cell division (growth is synonymous with reproduction).
Some organisms like mules, sterile worker bees, infertile human couples, etc., do not reproduce. Hence, reproduction also cannot be an all-inclusive defining characteristic of living organisms.

3. Metabolism
Metabolism is an another characteristic and defining feature of all living things. The sum total of anabolic or constructive reactions (anabolism) and catabolic or destructive reactions (catabolism) continuously occurring inside the body is called metabolism.
Metabolism —> Anabolism + Catabolism Metabolism occurs in all unicellular and multi cellular organisms. Its two stages include, i.e., anabolism, the process of building up or synthesis of complex substances from simpler ones, e.g., Photo synthesis and catabolism, the process of breakdown of complex substances into simpler substances, e.g., Respiration, releasing waste outside.
Metabolic reactions can also be demonstrated outside the body in cell free systems, which are neither living nor non-living. Thus, these reactions in vitro are surely living reactions not living things. Hence, metabolism can be considered as a defining feature of all living organisms without exception.
The important differences between anabolism and catabolism are

Anabolism	Catabolism
It is the sum total of constructive processes.	It is the sum total of destructive processes.
Complex substances are formed from simpler ones.	Simpler substances are formed from complex ones.
Energy is stored.	Energy is released.
Anabolism is required for growth and maintenance.	Catabolism is required for performance of activities.

Viruses are considered as non-living because they don't need energy for their activities, i.e., metabolic activities are altogether absent in them.

4. Cellular Organisation

The cells are the building blocks of all living things whether plants, animals or humans. The unicellular organisms are made of a single cell, while multi cellular organisms are formed by millions of cells. The cells contain protoplasm (living matter) and cell organelles (inside the cells) which perform several activities at the cellular level and result into various life processes.

5. Consciousness

All living organisms have excellent ability to sense their environment. They respond to various physical, chemical and biological stimuli.
The various external factors to which living organisms respond are light, water, temperature, pollutants, other organisms, etc. Light duration or photo period affects many seasonal breeders, plants as well as animals. All living things respond to chemicals, entering their * bodies.
Humans are superior to all living things as they have an additional ability of self-consciousness. Therefore, consciousness can also said to be a defining property of living organisms.
However, in human beings, it is more difficult to define living state, e.g., Patients lying in coma supported by machines that replace heart and lungs, are brain-dead with no self-consciousness.

6. Body Organisation

The body of living organisms is organised, i.e., several component and sub-components cooperate with each other for the functioning of whole body.

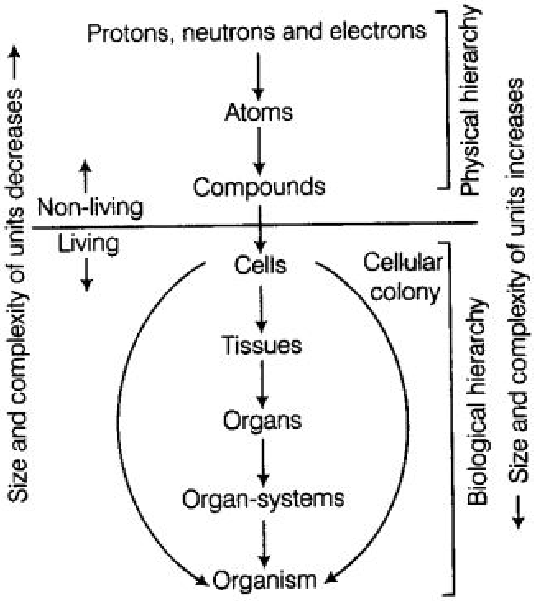

Fig. 1.2 Organisation in living organisms

Physical and Biological Hierarchies

There is a physical (non-living) hierarchy and biological hierarchy in the organisation of living body. In physical hierarchy, various non-living components aggregate to form compounds, which finally enter the living world in the form of cells. These cells organise to form tissues, that form organs and several organs combustive to form organ-systems. Finally, many organ systems organise and form a living organism.

The properties of tissues are not present in the constituent cells but arise as a result of interactions among the constituent cells. For example, bone is a hard tissue, which provides framework to the body. But, the cells present inside it do not have this property. This phenomenon of interactions between various components of the body results in the hierarchy of organisation.

The various life processes are the result of this interaction and coordination. The complexity in organisation enable living organisms as to be self-replicating, evolving, self-regulating and responding to external stimuli. All living organisms along with their ancestors and descendants are linked to one another by sharing of common genetic material in the form of DNA in varying degrees. This DNA is responsible for the expression of specific traits in organisms. Thus, Biology is the story of life on earth. It is the story of evolution of living organisms on the earth.

Some Other Characteristics of Living Organisms
We have discussed some important and defining characteristics of living things. However, organisms . also have many other features that differentiate them from non-living things, such as, shape & size, life cycle, movement, self-regulation, variations, adaptations, healing & repair, excretion and death.

2. Living World : Diversity and Taxonomy

The earth hosts an immense variety of living organisms. According to a survey, the number of species that are known and described are between 1.7-1.8 million.
This number refers to the biodiversity on the earth. The term Biodiversity or Biological diversity means the number and types of organisms present on the earth, forms of life in the living world. The living world includes all the living organisms, such as microorganisms, plants, animals and humans.
Biodiversity is not limited to the existing life forms. If we explore new areas and even old ones, new organisms are continuously being added. This huge available variety cannot be studied and identified without having a proper system of classification and nomenclature.

Systematics
The word 'Systematics' is derived from the Latin word Systema, which means systematic arrangement of organisms. Linnaeus used Systema Naturae as the title of his book. He. coined the term Systematics in 1751.
Systematics is the branch of science that deals with unique properties of species and groups to recognise, describe, name and arrange the diverse organisms according to an organised plan.
In 1961, Simpson, defined systematics as the study of diversity of organisms and all their comparative and evolutionary relationships based on comparative' anatomy, physiology, biochemistry and ecology. The word 'Systematics' and 'Taxonomy' are often used interchangeably by the biologists. Systematics includes the following:

Identification
It aims at finding the correct name and appropriate position of an organism. The morphological and anatomical characters are examined for proper identification.

Classification
It is almost impossible to study all the living organisms. So, it is necessary to devise some means to make this possible. This can be done by classifying the

organisms.
Thus, classification is the process by which organisms are grouped into categories based on some easily observable characters.
Biological classification is the scientific arrangement of organisms in a hierarchy of groups and sub-groups on the basis of similarities and differences in their traits.

Advantages of Classification
(a) It helps to identify an organism easily.
(b) New organisms easily get correct place in their respective groups.
(c) It makes study of fossils easy.
(d) It also helps in building evolutionary pathways.
(e) It becomes easy to know the features of whole group by studying one or two organisms of the group.
Thus, based on these characteristics, all living organisms are classified into different taxa.

Nomenclature

Nomenclature is the system of naming living organism in a way that a particular organism is known by the same name all over the world.
i. Common Names
The common names or vernacular names are the local names given to an organism in a specific language in a particular region. There are different names of a same organism in different regions even with in a country.

Organisms	Common Names
Rose	Gulab (Hindi), Golap (Bangla), Rajapo (Tamil)
Dog	Kukur (Bangla), Kutta (Hindi), Kutto (Gujarati), Svan (Sanskrit), Nay (Tamil)
Cat	Billi (Hindi), Biladi (Gujarati), Marjara (Sanskrit), Poonai (Tamil)
Cotton	Kapas (Hindi), Hatti (Kannada), Kapus (Marathi), Paruthi (Tamil), Karpus (Bengali)
Ginger	Adrakh (Hindi), Shunti (Kanada), Ale (Marathi), Ada (Bengali)

Advantages of Common Names
(a) Common names are easy to pronounce and are short, e.g., Cat or billi.
(b) People are familiar to these names since childhood.

(c) They are based on some features of organisms, e.g., Cowa (crow—Caawn-Caawn sound).

Dis-Advantages of Common Names

(a) All the organisms cannot be named by this method as there are organism of different sizes and shapes.
e.g., Microbes.
(b) An organism may have several names in a given language, e.g., 8 Hindi names of prickly poppy and water lily has 15 English names.
(c) A common names may have different meanings in different countries, e.g., Maize, means wheat and other grains in USA and it is called corn in common wealth countries.
(d) Common names may have little relevance, e.g., Lady's finger (okra), widows tears (Tradescantia-Rhoeo), etc.
(e) Common names may be incorrect, e.g., Jelly fish (a coelenterate), silverfish (an arthropod), starfish (an echinoderm) are not real fishes.
(f) These names are not useful for scientific studies.

ii. Scientific Names

A scientific name is given by biologists. These names represent a particular organism in every part of the world. The system of providing scientific names is called binomial nomenclature.
The scientific names must be
(a) acceptable in every part of the world.
(b) assigned on agreed principles and criteria.
(c) different for each species and not used for other organisms earlier.

Binomial Nomenclature

Binomial nomenclature was developed by Carolus Linnaeus in 1751 (Philosphica Botanica). All scientific names for animals under binomial nomenclature were given by Linnaeus in the tenth edition of his book Systerna Naturae (1758). Linnaeus named plants according to binomial nomenclature in his book Species Plantarum (1753). Binomial nomenclature is the system of providing distinct and appropriate names to organisms, each consisting of two words, first generic name {i.e., name of genus) and second specific epithet (i.e., name of species).
For example, Scientific name of mango is written as Mangifera indica. In this name, Mangifera represents the genus and indica is a particular species or specific epithet.

Binomial Nomenclature of Some Common Plants and Animals

Common Names	Binomial Nomenclature
Plants	
Pea	*Pisum sativam*
Onion	*Allium cepa*
Mango	*Mangifera indica*
Wheat	*Triticum aestivum*
Banyan	*Ficus benghalensis*
Soyabean	*Glycine max*
Animals	
Frog	*Rana hexadactyla*
Cat	*Felis catus*
Dog	*Canis familiaris*
Housefly	*Musca domestica*
Cobra	*Naja naja*
Common crap (fish)	*Cyprinus carpio*
Humans	*Homo sapiens*
Western honeybee	*Apis mellifera*

Rules of Binomial Nomenclature

Rules of binomial nomenclature were initially framed by Linnaeus in his books, Species Plantarum and Systema Naturae.

The rules were revised again by the following nomenclature codes

(i) International Code for Botanical Nomenclature (ICBN).
(ii) International Code of Zoological Nomenclature (ICZN).
(iii) International Code of Bacteriological Nomenclature (ICBN).
(iv) International Code of Viral Nomenclature (ICVN).
(v) International Code of Nomenclature for Cultivated Plants (ICNCP).

The rules framed by Linnaeus and by these codes are as follows

(i) The names are generally in Latin and written in italics. They are Latinised or derived from Latin irrespective of their origin.
(ii) The first word in a biological name represent the genus while, the second component denotes the specific epithet.

(iii) Both the words in a biological name, when handwritten are separately underlined or printed in italics to indicate their Latin origin.
(iv) The first word denoting the genus starts with capital letter while, the specific epithet starts with a small letter, e.g., Mangifera indica.
(v) Generic and common names may be same, e.g., Gorilla gorilla.
(vi) No names are recognised prior to those used by Linnaeus in 1753 for plants in Species Plantarum and in 1758 for animals in the 10th edition of Systema Naturae.
(vii) The name of categories higher than the rank of genus are not printed in italics. Bold letters can, however be used.
(viii) When a species is transferred or revised, the name of the original worker is retained but in parenthesis, e.g., Syzygium cumini (L) Skeels.

Advantages of Binomial Nomenclature
(i) Binomial names are universally acceptable and recognised.
(ii) They remain same in all languages.
(iii) The names are small and comprehensive.
(iv) There is a mechanism to provide a scientific name to every newly discovered organism.
(v) The names indicate relationship of a species with other species present in the same genus.
(vi) A new organism can be easily provided with a new scientific name.

Taxonomy

It is the science of identification, classification and nomenclature. Based on their special / characteristics, all living organisms can be classified into different taxa. This process of classification is called taxonomy. Carolus Linnaeus is known as father of taxonomy.
The basis of modern taxonomy studies are external and internal structure (comparative morphology), along with the structure of cells (cytology), development process (embryology) and ecological information of organisms (ecology). It provide information according to similarities, dissimilarities and evolutionary relationships of various organisms.

The basic processes for taxonomic studies are
(i) Organisms are described on the basis of morphology and other characteristics.
(ii) The description of characteristics helps in the placement of the organism in various taxa.

(iii) A new taxon can be framed if the organism is different from the existing taxa.
(iv) The correct naming of an organism can be done after placing it in various taxon.
A new organism can be given a new name after following the standardized rules.

Comparison between Taxonomy and Systematics

Taxonomy	Systematics
It is related to identification, nomenclature and classification.	It is the science of identification, nomenclature, description and classification.
Taxonomic studies are based on rules and principles of classification.	Systematics is related to unique properties at every level of classification.

Classical Taxonomy (Old Taxonomy)

The concept of classical or old taxonomy exists since, the time of Aristotle and Theophrastus and continued up to Linnaeus. It states that 4 .

(i) Species is the basic unit of taxonomy, that can be described on the basis of one or few preserved specimens.
(ii) Species are fixed and do not change with time.
(iii) A species is delimited based on morphological features.
(iv) Organisms are classified on the basis of some limited features such as root modification, leaf venation, floral structures, number of cotyledons in case of plants.

Due to the limited number of groups, many organisms could not be classified correctly. This finally led to artificial system of classification.

Modern Taxonomy (New Taxonomy)

The concept of modern taxonomy was given by Julian Huxley (1940). It uses evidences from all the areas of biology like morphology, anatomy, biochemistry, cell biology, physiology, genetics, evolution, etc.

The modem taxonomy is based on the following features

(i) The studies are done on a huge number of organisms based on all the variations.
(ii) Study is also focused on sub-species, varieties, races and populations.
(iii) Species are not isolated. They are related by common descent and vary from them due to accumulation of variations.
(iv) Species is considered as dynamic and ever-changing entity.
(v) Biological delimitation includes various branches of systematics, e.g., Cytotaxonomy, experimental taxonomy, numerical taxonomy, chemotaxonomy, etc.

This led to the development of phylogenetic system or cladistics of classification.

Taxonomic Categories

Classification is not a single step process. It involves hierarchy of steps in which each step represents a rank or category. Since, the category is a part of overall taxonomic arrangement, it is called the taxonomic category and all categories together constitute the taxonomic hierarchy.

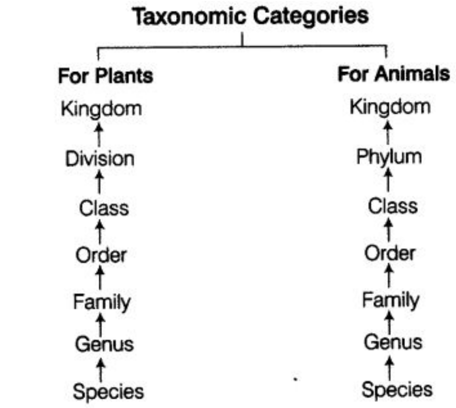

Fig. 1.3 Taxonomic categories showing hierarchial arrangement in ascending order

Taxon

Each category, referred to as a unit of classification, in fact, represents a rank and is commonly termed as taxon (Pi. taxa). The term Taxon was first introduced by ICBN during 1956.

According to Mayr (1964) taxon is a group of any rank that is sufficiently distinct to be worthy of being assigned a definite category. In simple words, taxon refers to a group of similar, genetically related individuals having certain characters distinct from those of other groups.

A taxon that includes a common ancestral species and all the species descended from it is called a clade or a monophyletic taxon.

Taxon	Category
A taxon deals with real biological objects.	A category is an abstract term that simply represents a rank or level in classification.
Taxon may belong to any ranking.	It belongs to one particular ranking.
e.g., The taxon of humans is mammalia.	e.g., The category of humans is class.

Taxonomic Hierarchy

The taxonomic hierarchy is the system of arranging taxonomic categories in a descending order. It was first introduced by Linnaeus (1751) and hence, it is also known as Linnaen hierarchy.

Groups represent category and category further denotes rank. Each rank or taxon

represents a unit of classification.
These taxonomic groups/categories are distinct biological entities and not merely morphological aggregates.

Obligate/Common Categories
The taxonomic categories, which are always used in hierarchical classification of organisms are called obligate or common categories.
They are seven in number. In descending order, these are kingdom, phylum or division, class, order, family, genus and species.
All the members of taxonomic categories possess some similar characters, which are different from those of others. The maximum similarity occurs in species, which is also the lowest category in the hierarchy of categories. Similarity of characters decreases with the rise in hierarchy.

i. Species
Taxonomic studies consider a group of individual organisms with fundamental similarities as a species (John Ray).

Some Organisms with their Taxonomic Categories

Common Name	Scientific Name	Species	Genus	Family	Order	Class	Phylum (Division)	Kingdom
Human	*Homo sapiens*	*sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata	Animalia
Dog	*Canis familiaris*	*familiaris*	*Canis*	Canidae	Carnivora	Mammalia	"	"
Housefly	*Musca domestica*	*domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda	"
Mango	*Mangifera indica*	*indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae	Plantae
Tulsi	*Ocimum sanctum*	*sanctum*	*Ocimum*	Lamiaceae	Lamiales	"	"	"
Wheat	*Triticum aestivum*	*aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	"	"

Species is considered as the lowest or basic taxonomic category, which consists of one or more individuals of a populations that resemble one another more closely than individuals of other species. The members of species interbreed freely and are reproductively isolated from others. For example, Mangifera indica (mango), Solarium tuberosum (potato) and Panthera leo (lion).

All the three names indica, tuberosum and leo represent the specific epithets while, the first words Mangifera, Solanum and Panthera are genera and represents another higher level of taxon or category.
Each genus may have one or more than one specific epithets representing different organisms, but having morphological similarities. For example, Panthera has another specific epithet called tigris and Solanum includes species like nigrum and melongena.

ii. Genus

Genus (John Ray) comprises a group of related species, which has more characters common in comparison to species of other genera. In other words, genera are aggregates of closely related species.

Some Genus and their Species

Genus	Species
Solanum	Potato (*Solanum tuberosum*) and Brinjal (*S. melongena*)
Panthera	Lion (*Panthera leo*), Leopard (*P. pardus*) and Tiger (*P. tigris*)
Felis	Common cat (*Felis catues*), Jungle cat (*F. chaus*) and Golden cat (*F. temminccii*)
Equus	Horse (*Equus ferus cabalus*), Ass (*E. africanus acinus*) and Zebra (*E. quagga*)

iii. Family

Family (John Ray) is a group of related genera with less number of similarities as compared to genus and species. All the genera of a family have some common or correlated features. They are separable from genera of a related family by important differences in both vegetative and reproductive features.

A plant family ends in a suffix -aeae and sub-family -oideae. While, an animal family has a suffix -idae and sub-family -inae.

iv. Order

An order (Linnaeus) is a group of one or more related families that possess some similar correlated characters, which are lesser in number as compared to a family or genera.

Plants and Animal Orders with their Respective Families

Order Animals and Families

Carnivora Canidae (dog, wolf and fox), Felidae (cat, leopard, tiger and lion), Ursidae (bear) and Hyaenidae (hyaena)

Polemoniales Solanaceae (potato and tomato), Convolvucaceae (sweet potato and morning glory), Polemoniaceae (herbs, shrubs and small trees) and Hydrophyllaceae (water leaf).

Primates Lemuridae (lemurs), Cebidae (new world monkeys), Pongidae (apes) and Hominidae (humans).

Order	Animals and Families
Carnivora	Canidae (dog, wolf and fox), Felidae (cat, leopard, tiger and lion), Ursidae (bear) and Hyaenidae (hyaena)
Polemoniales	Solanaceae (potato and tomato), Convolvucaceae (sweet potato and morning glory), Polemoniaceae (herbs, shrubs and small trees) and Hydrophyllaceae (water leaf).
Primates	Lemuridae (lemurs), Cebidae (new world monkeys), Pongidae (apes) and Hominidae (humans).

v. Class

Class (Linnaeus) is a major category, which includes related orders. For example, order-Primata comprises monkey, gorilla & gibbon and is placed in class—Mammalia along with order—Carnivora that includes animals like tiger, cat and dog.
Class-Mammalia has other orders also.

vi. Phylum or Division

Phylum or Division (Cuvier, Eichler) is a taxonomic category higher than class and lower" in rank to kingdom. The term Phylum is used for animals, while division is commonly employed for plants.
It consists of more than one class having some similar corelated characters.
For example, Phylum— Chordata of animals contain following classes, e.g., Pisces, amphibians, reptiles, aves and mammals.

vii. Kingdom

It is known to be the highest category in taxonomy. This includes all the organisms, which share a set of distinguished characters. For example, all the animals belonging to various phyla are assigned the highest category called kingdom.
For example, Animalia in the classification system of animals. Similarly, all the plants are kept in kingdom—Plantae.
RH Whittaker. (1969) assigned five kingdom classification of organisms.
These are Monera, Protista, Fungi, Plantae and Animalia.

Intermediate Categories

The taxonomic categories from species to kingdom are broad categories or obligate categories. However, taxonomists have also developed sub-categories in this hierarchy to facilitate more sound and scientific placement of various taxa.
These sub-categories are sub-species (or varieties), sub-genera, sub-families, sub-orders, sub-classes and sub-phyla.
These sub-categories are referred to as intermediate categories.

Taxonomical Aids

Taxonomical aids are techniques and procedures to store information as well as specimens or identification and classification of organisms.

The taxonomic studies of various plants, animals and other organisms are useful in areas like agriculture, forestry, industry and knowing our bioresources. All these studies need correct identification and classification of organisms. Identification of organisms requires intensive laboratory and field studies. The collection of actual specimens of plants and animal species, knowing their habitats and other traits are essential and are the prime source of taxonomic studies. All this information is used in classification of an organism and is also stored along with the specimens. Sometimes, specimens are also preserved for future studies.
Some of the taxonomical aids developed by Biologists include Herbarium, Botanical gardens, Museum, Zoological parks, Key, etc.

1. Herbarium
Herbarium (Pi. Herbaria) is a store house of collected plant specimens that are dried, pressed and preserved on sheets. These sheets are arranged further according to a universally accepted system of classification. The institutes and universities maintain their own herbarium by collecting specimens from local and far away places.

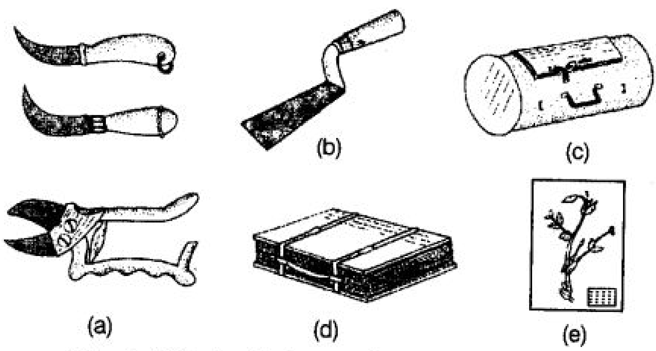

Fig. 1.4 Tools of plant collection (a) Cutters (b) Digger (khurpi) (c) Vasculum (d) Plant press (e) Herbarium sheet

Some Famous Herbaria of the World

Herbarium Name	Place	No. of Herbarium Specimens
Royal Botanical Gardens (largest herbarium)	Kew (London)	6.5 million
Museum of Natural History	Paris	Over 6 million
New York Botanical Garden	New York (USA)	4.0 million
US National Herbarium	Washington (USA)	Over 3 million
British Museum of Natural History	London	3 million
Central National Herbarium	Sibpur Kolkata (India)	2.0 million
Madras Herbarium	Coimbatore (India)	150000
National Botanical Research Institute	Lucknow (India)	80000

Uses of Herbaria

The uses of herbaria are listed below

(a) These are used for identification of plants.
(b) Compilation of floras, monographs and manuals are mainly based on the specimens in herbaria.
(c) Herbaria are useful in locating wild varieties and relatives of economically important plants.
(d) They help in knowing the morphological variations found in species.
(e) Herbaria are useful for research in plant taxonomy, morphology, ecological distribution, etc.

2. Botanical Gardens

Botanical gardens are specialised gardens that have collections of living plants for reference. These gardens generally have facilities like library, laboratory, herbarium and museum. The botanical gardens are maintained by government, semi-government and other private organisations. Botanists and gardeners look after plants in botanical gardens.

Some Major Botanical Gardens

Botanical Garden	Place
Royal Botanical Garden	Kew (London)
New York Botanical Garden	New York (USA)
Berlin Botanical Garden and Museum	Berlin (Germany)
Cambridge University Botanical Garden	Cambridge (UK)
Indian Botanical Garden	Howrah, Kolkata (India)
Lloyed Botanical Garden	Darjeeling (India)
National Botanical Garden	Lucknow (India)

Role of Botanical Gardens

A botanical garden has following important roles

(a) Botanical gardens have aesthetic appeal and provide recreation facility to people.

(b) A wide variety of plant species grow there, so they provide ready material for research.

(c) These gardens also play an important role in conservation of endangered plant species and genetic diversity.

(d) There are more than 500 botanical gardens all over the world. These provide free exchange of seeds.

(e) These improve the environment, provide greenery, help in creating pollution free environment and some serves as habitat for animals.

Knowledge Plus

Indian Botanical Garden-Largest Botanical Garden of Asia.

First Botanical Garden-Pisa Botanical Garden, Italy established by Luca Glini (1490-1556).

3. Museums

Museum is a place for collections of preserved plants and animal specimens for study and reference. The universities and educational institutes maintain their own museums in their botany and zoology departments. Plants, which cannot be kept in herbaria are preserved in museums.

For example, algae, fungi, mosses, ferns, fruits, etc. Specimens are preserves in containers or jars in preservative solutions. Plant and animal specimens may also be preserved as dry specimens. Insects are preserved in insect boxes after collecting killing and pinning. While, the larger animals are stuffed and preserved in skeletal forms.

Some Important Museums of other Countries and India

Museums	Place
American Museums of Natural History	New York (USA)
Museum of Natural History	Basel (Switzerland)
Natural History Museum	London
Zoological Museum	Amsterdam (Netherland)
Bird Collection Museum of Natural History	Vienna (Austria)
National Museum of Natural History	Paris
National Museum of Natural History	Delhi (India)
Prince of Wales Museum	Mumbai (India)
Museum of Arthropoda	Pune (India)

4. Zoological Parks

Zoological parks or zoo are the places where wild animals are kept in protected environments under human care and which enable us to learn about their food habits and behaviour. Zoological parks provide natural habitat to the animals.
In India there are about 200 zoological parks. These zoos are managed by the Central Zoo Authority of India. The World Zoo Conservation Strategy (WZCS) refer to all these zoological institutions as zoos.

Role of Zoological Parks

(a) The zoological parks increase understanding of wildlife.
(b) These are the centres for recreation and education.
(c) Zoos are the centres for conservation of threatened and rare animal species.
(d) These provide sites for ex situ breeding of endangered animals. conservation through captive breeding of endangered animals.

5. Key

Key is also a taxonomical aid used for identification of plants and animals based on the similarities and dissimilarities.
It helps in the identification of plants and animals by selecting and eliminating the characters according to their presence or absence in the organism under study.
The keys generally use two contrasting characters called couplet. This results in acceptance of one present in organism and rejection of the other. Each statement in the key is called a lead.
These taxonomic keys are of two types

Indented Key
The indented key or yolked key provides a sequence of choices between two or more characteristics. By careful selection of characters at each sub-division, the exact name of the organism can be arrived at.

Bracketed Key
The bracketed key also uses contrasting characters like the indented key. But in, these characters are not separated by intervening sub-dividing characters. Each character in this case is given a number in brackets.

Other Means of Recording Descriptions
Apart from the all mentioned means of keeping records of description. Some other means are also present.

These are of following types
Flora
Floras are the important resource that provide information on the taxonomy, nomenclature and descriptive data for the taxa covered.
The floras also include information on the biology, distribution and habitat preferences of the taxa, as well as illustrations, identification keys and other notes. These provide index to the plant species found in a particular area.

Manuals and Catalogues
These are other means of recording descriptions. They also help in correct identification. Manuals are useful in providing information for identification of names of species found in an area.

Monograph
A monograph is a comprehensive treatment of a taxon in biological taxonomic studies. These contain information on any one taxon. Monographs revise all known species within a group, add any newly discovered species, collect and organise available information on the ecological associations, geographic distributions and morphological variations within the group.
The first ever monograph of a plant taxon was given in Robert Morison (1672) Plantarum Umbelliferarum Distributio Nova.

The Living World Class 11 MCQs Questions with Answers

Question 1.
Identify the incorrect match.
(a) Physiology – Study of functions and processes of life
(b) Pedology – Soil science
(c) Limnology – Study of fresh water
(d) Kinesiology – Fossil study
Answer
Answer: (d) Kinesiology – Fossil study
Question 2.
The Phylogenetic system of classification was put forth by
(a) Theophrastus
(b) George Bentham and Joseph Dalton Hooker
(c) Carolus Linnaeus
(d) Adolf Engler and Karl Prantl
Answer
Answer: (d) Adolf Engler and Karl Prantl
Question 3.
Two taxonomic species are distinguished from each other by
(a) their failure to interbreed
(b) their ability to exchange gene freely
(c) their similarity in morphological characters
(d) discontinuity in a set of correlated characters
Answer
Answer: (a) their failure to interbreed
Explanation:
Two taxonomic species are distinguished from each other by their failure to interbreed.
Question 4.
Musca domestica is common name of
(a) Housefly
(b) Mosquito
(c) Snail
(d) Ant
Answer

Answer: (a) Housefly
Explanation:
Musca domestica is the common name of housefly.
Question 5.
Keystone species are
(a) important for ecosystem
(b) important for plants
(c) endangered species
(d) extinct species
Answer
Answer: (a) important for ecosystem
Explanation:
Keystone species are plants or animals species that play a unique and crucial role in the way an ecosystem functions.
They are very important for ecosystem to function properly.
Question 6.
The study of fish culture is called
(a) ophiology
(b) herpetology
(c) ichthyology
(d) pisciculture
Answer
Answer: (d) pisciculture
Question 7.
National Botanical Research Institute is located in
(a) Shimla
(b) Dehradun
(c) Howrah
(d) Lucknow
Answer
Answer: (d) Lucknow
Explanation:
National Botanical Research Institute is located in Lucknow.
Question 8.
Biosystematics aims at
(a) Identification and arrangement of organisms on the basis of cytological characteristics
(b) The classification of organisms based on broad morphological characters

(c) Delimiting various taxa of organism and establishing their relationships
(d) The classification of organisms based on their evolutionary history and establishing their phylogeny on the totality of various parameters from all fields of studies
Answer
Answer: (d) The classification of organisms based on their evolutionary history and establishing their phylogeny on the totality of various parameters from all fields of studies
Question 9.
In angiosperm, characters of flowers are used in classification because
(a) Flowers are attractive
(b) Flowers are large
(c) Characters of flowers are conservative
(d) None of the above
Answer
Answer: (c) Characters of flowers are conservative
Question 10.
Scientific name of plants are given by
(a) International code for Botanical nomenclature
(b) International code for biological plants
(c) Indian code for Botanical nomenclature
(d) International code for zoological nomenclature
Answer
Answer: (a) International code for Botanical nomenclature
Explanation:
The scientific names of plants are given by International code for Botanical nomenclature.
Question 11.
A system which gets a continuous flow of energy is called
(a) micropropagated system
(b) closed system
(c) open system
(d) steady state
Answer
Answer: (c) open system
Question 12.
Solanum, Panthera, Homo are examples of
(a) Family

(b) Division
(c) Genera
(d) Species epithet
Answer
Answer: (c) Genera
Explanation:
Solanum, Panthera, Homo are examples of generic names.
Question 13.
Which of the following is correct?
(a) Musca domestica Order – Diptera Family – Muscidae Phylum – Arthropoda
(b) Mangifera indica Order – Sapindales Family – Anacardiaceae Phylum – Gymnospermae
(c) Triticum aestivum Order – Poles Family – Monocotyledons Phylum – Angiospermae
(d) Panthera leo Order – leo Family – Felidae Phylum – Mammalia
Answer
Answer: (a) Musca domestica Order – Diptera Family – Muscidae Phylum – Arthropoda
Explanation:
Mangifera indica belongs to Phylum Angiospermae.
Triticum aestivum belongs to family Poaceae.
Panthera leo belongs to order Carnivora.
Question 14.
Binomial Nomenclature was given by
(a) Ernst Mayr
(b) Alexander Agassiz
(c) Carolus Linnaeus
(d) Alexander Agassiz and Carlous Linnaeus
Answer
Answer: (c) Carolus Linnaeus
Explanation:
The system of providing scientific names with two components i.e. generic name and specific epithet is called Binomial Nomenclature.
Binomial Nomenclature was given by Carolus Linnaeus.
Question 15.
Systematics deals with
(a) Nomenclature of new organisms
(b) Evolutionary relationship between organisms

(c) Identification of newly discovered organisms
(d) All of these
Answer
Answer: (d) All of these
Explanation:
Linnaeus used Systema Naturae as the title of his publication.
The scope of systematics includes identification, nomenclature and classification.
Systematics takes into account evolutionary relationship between organisms.
Question 16.
Which of the following shows maximum diversity?
(a) Plantas
(b) Animalia
(c) Monerans
(d) Protistans
Answer
Answer: (b) Animalia
Question 17.
Which of the following does not come under taxon?
(a) Species
(b) Kingdom
(c) Division
(d) Key
Answer
Answer: (d) Key
Explanation:
Taxon is a group of one or more population of organisms.
Kingdom, division and species come under taxon but key is taxonomical aid.
Question 18.
The ozone layer is found in the
(a) hydrosphere
(b) stratosphere
(c) lithosphere
(d) troposphere
Answer
Answer: (b) stratosphere
Question 19.
Taxonomic studies depends on
(a) Ecological information of organisms.

(b) Structure of cell and development process of organisms.
(c) External and internal structure of organisms.
(d) All of the above.
Answer
Answer: (d) All of the above.
Explanation:
Taxonomic studies depends on ecological information of organisms, structure of cell and development process of organism and external and internal structure of organisms.
Question 20.
Wheat belongs to division _______.
(a) Angiospermae
(b) Gymnospermae
(c) Poacae
(d) None of the above
Answer
Answer: (a) Angiospermae
Explanation:
Wheat belongs to Angiospermae division.

Solutions For Class 11 Biology Chapter 1 The Living World

Chapter 1 The Living World:

Section Name	Topic Name
1	The Living World
1.1	What is 'Living'?
1.2	Diversity in the Living World
1.3	Taxonomic Categories
1.4	Taxonomical Aids
1.5	Summary

TEXTBOOK QUESTIONS SOLVED

1. Why are living organisms classified?
Soln. Living organisms are classified because of the following reasons:
(i) Easy identification.

(ii)Study of organisms of other places.
(iii)Study of fossils
(iv)Grouping helps in study of all types of organisms while it is impossible to study individually all of them.
(v) Itbringsoutsimilaritiesanddissimilarities. They help in knowing relationships among different groups.
(vi)Evolution of various taxa can be known.

2. Why are the classification systems changing every now and then?
Soln. From very early days till now biologists use several characters for classification system. These are morphology, anatomy, cytology, physiology, ontogeny, phylogeny, reproduction, biochemistry, etc. But day by day biologists are learning something new about organisms from their fossil records and using" advanced study techniques such as molecular phylogeny, etc. So their point of view about classification keeps changing. Thus the system of classification is modified every now and then.

3. What different criteria would you choose to classify people that you meet often?
Soln. The various criteria that may be chosen to classify people whom we meet often include behaviour, geographical location, morphology, family members, relatives, friends etc.

4. What do we learn from identification of individuals and populations?
Soln. The knowledge of characteristic of an individual or its whole population helps in identification of similarities and dissimilarities among the individuals of same kind or between different types of organisms. It helps us to classify the organisms in various categories depending upon these similarities and dissimilarities.

5. Given below is the scientific name of mango. Identify the correctly written name.
Mangifera Indica Mangifera indica
Soln. The correctly written scientific name of mango is Mangifera indica.

6. Define a taxon. Give some example of taxa at different hierarchical levels.
Slon. A taxonomic unit in the biological system of classification of organism is called taxon (plural taxa). For example a phylum, order, family, genus or species

represents taxon. It represents a rank. For example, all the insects form a taxon. Taxon of class category for birds is Aves and taxon of Phylum category for birds is Chordata. The degree of relationship and degree of similarity varies with the rank of the taxon. Individuals of a higher rank, say Order or Family, are less closely related than those of a lower rank, such as Genus or Species.

7. Can you identify the correct sequence of taxonomical categories?
(a) Species —> Order —> Phylum —> Kingdom
(b) Genus—) Species—> OrderKingdom
(c) Species —> Genus —>Order —> Phylum
Slon. The correct sequence of taxonomical categories is
(c) i.e., Species —>Genus —> Order —> Phylum.

8. Try to collect all the currently accepted meanings for the word 'species'. Discuss with your teacher the meaning of species in case of higher plants and animals on one hand, and bacteria on the other hand.
Slon. Species occupies a key position in classification. It is the lowest taxonomic category. It is a natural population of individuals or group of populations which resemble one another in all essential morphological and reproductive characters so that they are able to interbreed freely and produce fertile offsprings. Each species is also called genetically distinct and reproductively isolated natural population. Mayr (1964) has defined species as "a group of actually or potentially interbreeding populations that are reproductively isolated from other such groups".
In higher plants and animals the term 'species' refers to a group of individuals that are able to interbreed freely and produce fertile offsprings. But, in case of bacteria interbreeding cannot serve as the best criteria for delimiting species because bacteria usually reproduce asexually. Conjugation, transformation and transduction, which are termed as sexual reproduction methods in bacteria, also do not correspond to true interbreeding. Thus, for bacteria many other characters such as molecular homology, biochemical, physiological, ecological and morphological characters are taken into consideration while classifying them.

9. Define and understand the following terms:
(i) Phylum (ii) Class (iii) Family
(iv) Order (v) Genus
Slon. (i) Phylum – Phylum is a category higher than that of Class. The term Phylum is used for animals. A Phylum is formed of one or more classes, e.g., the Phylum

Chordata of animals contains not only the class Mammalia but also Aves (birds), Reptilia (reptiles), Amphibia (amphibians), etc. In plants the term Division is used in place of Phylum.
(ii) Class – A Class is made of one or more related Orders. For example, the Class Dicotyledoneae of flowering plants contains all dicots which are grouped into several orders (e.g., Rosales, Sapindales, Ranales, etc.).
(iii) Family, – It is a taxonomic category which contains one or more related genera. All the genera of a family have some common features or correlated characters. They are separable from genera of a related family by important and characteristic differences in both vegetative and reproductive features. E.g., the genera of cats (Fells) and leopard (Panthera) are included in the Family Felidae. The members of Family Felidae are quite distinct from those of Family Canidae (dogs, foxes, wolves).
Similarly, the family Solanaceae contains a number of genera like Solanum, Datura, Petunia and Nicotiana. They are distinguishable from the genera of the related family Convolvulaceae (Convolvulus, Ipomoea).
(iv) Order – The category includes one or more related families. E.g., the plant Family Solanaceae is placed in the Order Polemoniales alongwith four other related families (Convolvulaceae, Boraginaceae, Hydrophyllaceae and Polemoniaceae). Similarly, the animal families Felidae and Canidae are included under the Order Carnivora alongwith Hyaenidae (hyaenas) and Ursidae (bears).
(v) Genus – It is a group or assemblage of related species which resemble one another in certain correlated characters. Correlated characters are those similar or common features which are used in delimitation of a taxon above the rank of species. All the species of genus are presumed to have evolved from a common ancestor. A genus may have a single living species e.g., Genus Homo. Its species is Homo sapiens – the living or modem man. The Genus Felis has many species, e.g., F. domestica – common cat, F. chaus (jungle cat) etc.

10.How is a key helpful in the identification and classification of an organism?
Slon.'Key is an artificial analytic device having a list of statements with dichotomic table of alternate characteristics. Taxonomic
keys are aids for rapid identification of unknown plants and animals based on the similarities and dissimilarities. Keys are primarily based on stable and reliable characters. The keys are helpful in a faster preliminary identification which can bebacked up by confirmation through comparison with detailed description of the taxon provisionally identified with. Separate taxonomic keys are used for each taxonomic category like Family, Genus and Species.

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11.Illustrate the taxonomical hierarchy with suitable examples of a plant and an animal.

Slon. The arrangement of various taxa in a hierarchical order is called taxonomic hierarchy. The hierarchy indicates the various levels of kinship. The number of similar characters of categories decreases from lowest rank to highest rank. The hierarchical system of classification was introduced by Linnaeus.

The hierarchy of major categories is:

Species —►Genus-►Family —► Order—► Class

Kingdom -4— Phylum or Division

Increasing specificity – ► Decreasing specificity

Classification of a plant (Wheat):

Kingdom – Plantae
Division – Angiospermae
Class – Monocotyledonae
Order – Poales
Family – Poaceae
Genus – Triticum
Species – aestivum

Classification of an animal (Housefly):

Kingdom – Animalia
Phylum – Chordata
Class – Insecta
Order – Diptera
Family – Muscidae
Genus – Musca
Species – domestica

Biological Classification Class 5 Notes Biology

Biological classification is the scientific procedure of arranging organisms in a hierarchical series of groups and sub-groups on the basis of their similarities and dissimilarities.

Need of Classification

There have been many attempts to classify living organisms since ancient times. Aristotle was the earliest to attempt a scientific basis of classification. He used simple morphological characters to classify plants as trees, shrubs and herbs. He also classified animals into two groups,
i.e„ enaima (with red blood) and anaima (without red blood). A need for proper system of classification was always felt.

Living organisms need to be classified because of the following reasons
(i) The study of one or two organisms is not sufficient to know the essential features of the group.
(ii) All kinds of organisms do not occur in one locality.
(iii) Classification helps in knowing the relationship among-est different groups of organisms.
(iv) It helps in knowing the evolutionary relationship between organisms.

Types of Classification System
Depending upon the types of system of classification, organisms are classified into following kingdoms

1. Two Kingdom Classification System
Linnaeus (the father of taxonomy system) divided all the living organisms into two kingdoms in 1758.

These are Plantae and Animalia.

Two Kingdom System

Plantae
- Algae
- Fungi
- Bacteria
- Bryophyta
- Pteridophyta
- Spermatophyta

Animalia
- Coelenterata
- Porifera
- Platyhelminthes
- Mollusca
- Nemathelminthes
- Annelida
- Echinodermata
- Chordata

Features of Kingdom-Plantae

The characteristic features of this kingdom are

(a) Cell wall is present.

(b) A big central vacuole is present.

(c) Absorb inorganic nutrieiAs from outside.

(d) Unlimited growth and well defined growing points.

(e) Autotrophic mode of nutrition, reserve food is starch.

(f) No locomotion (except in some lower algae).

(g) Absence of excretory organs, nervous system, sense organs and muscular system.

(h) Slow response to external stimuli.

Features of Kingdom-Animalia

The characteristic features ofthis kingdom are

(a) Absence of cell wall.

(b) Inorganic crystals are not present in their cells.

(c) Central vacuole is not present.

(d) Heterotrophic mode of nutrition.

(e) Growth is limited and well defined growing points are not present.

(f) Reserve food as glycogen.

(g) Excretory organs, nervous system and sense organs are present.

(h) Locomotion is present.

(i) Muscular system is present.

(j) Show quick response to external stimuli.

Objections Against Two Kingdom Classification System

The two kingdom system of classification was accepted for a long time. However, some difficulties arised from this classification as several new living organisms have been discovered.

Some of these difficulties are mentioned below
(a) The first formed organisms were neither plants nor animals.
(b) Fungi do not show similarity with structure, physiology and reproductive system of plants.
(c) It is not easy to recognise the lower organisms as plants or animals. For example, Euglena has mixotrophic (dual) mode of nutrition, while sponges are fixed, branched and irregular creatures like plants.
(d) Slime moulds, a group of fungi, are wall-less in vegetative phase. They develop cell wall in the reproductive phase. Slime moulds can neither be placed in fungi, nor plants.
(e) Lichens are formed by the symbiotic association of an alga and a fungus. They neither resemble plants nor animals.
(f) Prokaryotes do not have an organised nucleus. They have single envelope organisation, absence of spindle apparatus, meiosis and sexual reproduction. Eukaryotes have a well-defined nucleus, a double envelope organisation, spindle apparatus, meiosis and sexual reproduction.
On the other hand, viruses have no protoplasm and metabolic machinery of their own. Therefore, all of these cannot be kept in a single group.
(g) Unicellular algae like diatoms, euglenoids, dinoflagellates and Protozoa resemble each other.

2. Three Kingdom Classification System

Ernst Haeckel in 1866, classified living organisms into three kingdoms-Plantae, Protista and Animalia. The new kingdom-Protista included all those organisms, which lack the capability of tissue differentiation. These are algae, fungi and Protozoa. Later, kingdom-Protista was reserved only for unicellular organism.

Limitations of Three Kingdom Classification System

Limitations of three kingdom classification are
(a) Prokaryotes and eukaryotes are not separated.
(b) Both unicellular and multicellular organisms are kept in Protista.

3. Four Kingdom Classification System

The four kingdom classification system included Monera in addition to Protista, Plantae and Animalia. Studies with electron microscope made it clear that bacteria and related organisms have a different nuclear structure as compared to others. They are* prokaryotes, thus kingdom-Monera was created by Copeland (1956). Fungi continued to remain with Plantae in this system.

4. Five Kingdom Classification System
This classification was proposed by RH Whittaker, in 1969. Before 1969, the classification systems for the living organisms have undergone several changes overtime.
He created fungi, as separate kingdom.
The main criteria for classification used by Whittaker
(i) Cell structure (ii) Modes of nutrition
(iii) Thallus organisation (iv) Reproduction
(v) Phylogenetic relationships.

Merits of Five Kingdom Classification System
Merits of five kingdom classification system are
(a) Euglena and other transition types which had been included both amongst plants and animals are given proper place under kingdom—Protista.
(b) Fungi have their own biochemical, physiological and structural organisation. They have never been related to plants. In this system of classification fungi are separately placed.
(c) A separate kingdom of prokaryotes include Monera has been created. Monerans differ from all other organisms in their cellular, reproductive and physiological organisations.
(d) The five kingdom classification system is based on cellular organisation, the mode of nutrition and complexity of structure. These were the basic factors used in earliest two kingdom system of classification.
(e) The system shows the gradual evolution of early organisms into plants and animals.
(f) The plant and animal kingdoms are more homogenous than, they were in the two kingdom system of classification.

Demerits of Five Kingdom Classification System
Demerits of five kingdom classification system are
(a) Animal protozoans have been included in kingdom—Protista, which also includes unicellular plants. They show different modes of nutrition.
(b) Yeasts are though, unicellular eukaryotes, do not belong to kingdom—Protista.
(c) Chlorella and Chlamydomonas, though unicellular included under the kingdom-Plantae. They should be kept in Protista.
(d) Euglena like organisms and slime moulds with flexible life style may need the creation of an intermediate kingdom of Protista.
(e) Viruses and viroids are not kept in proper place in this system.

5. Six Kingdom Classification System

It was introduced by Carl Woese a Professor in the Department of Microbiology, University of Illinois in 1990. This system is also named as three domain system as in it organisms are classified into three domains, i.e., Archaea, Bacteria and Eukarya.

It mainly used basic principles of five kingdom system but divides the Monera into two domains Archaebacteria, Eubacteria and other eukaryotes in third kingdom.

i. Archaea

Archaea domain includes prokaryotic organisms. These are characterised by a mono layer core of lipids in the cell membrane and distinct nucleotides in their 16S RNA. It contains a single kingdom called Archaebacteria. Kingdom-Archaebacteria

This kingdom includes early prokaryotes, which live in extreme conditions of the environment. These are methanogens, halophiles and thermoacidophiles.

ii. Bacteria

The bacteria domain consists of typical prokaryotes that lack membrane covered cell organelles. These do not have microchambers for separating various metabolic activities. It also has a single kingdom-Eubacteria.

Kingdom-Eubacteria

The members of this kingdom have peptidoglycan cell wall, naked DNA in coiled form, glycogen food reserves.

The sap vacuole is not present and 70S ribosomes are present. The members of this kingdom are bacteria, mycoplasma, Actinomycetes, rickettsiae, spiro- chaetes, cyanobacteria, firmicutes.

iii. Eukarya

The domain eukarya contains all the eukaryotes. These living forms are originated by symbiotic association between some archaebacteria and eubacteria.

The four kingdoms ofthis domain are

(a) Protista

(b) Fungi

(c) Plantae

(d) Animalia

Characters	Archaea	Bacteria	Eukarya
Cell type	Prokaryotic	Prokaryotic	Eukaryotic
Histones	Have proteins similar to histones	No histones	Have histones
Introns	Some introns	No introns	Most contain introns
Ribosome size	70S ribosomes	70S ribosomes	80S ribosomes
Cell wall composition	Made of protein (but lack peptidoglycan)	Made of peptidoglycan	Not always present; Plants: Cellulose, Fungi: Chitin

2. Monerans and Protistans

As we have already read in the previous about the topic most widely accepted five kingdom classification given by Whittaker in general. Now, we will study in details about the monerans and protistans before the other three kingdoms. This is because, monerans are thought to have given rise to the protistans from which the remaining three has been evolved along the separate lines.

Kingdom Monera

The kingdom-Monera includes all prokaryotes such as bacteria, mycoplasma, Actinomycetes and cyanobacteria (blue-green algae).

The characteristic features of kingdomr-Monera are given below

(i) They are simplest or most primitive, unicellular prokaryotes.
(ii) The cell wall contains peptidoglycan or murein (no cellulose) and the membrane bound cell organelles are not present.
(iii) They have various types of nutrition like saprophytic, parasitic, chemoautotrophic, photoautotrophic and symbiotic.
(iv) DNA is naked. It lies inside the cytoplasm in coiled form. This is called nucleoid.
(v) The flagella, if present are single-stranded instead of being 11 stranded as in eukaryotes. These contain a protein called flagellin.
(vi) Reproduction is by asexual method. Gametes are not present.
(vii) Mitotic spindle is absent.
(viii) Some of the monerans have the ability to fix-nitrogen into useful nitrates.

I. Bacteria

The term Bacteria was proposed by Ehrenberg in 1829. They have widespread distribution be it air, water or soil. They can survive in extreme range of temperatures like up to 78°C and -190°C.

Important characteristics of bacteria are
(i) Bacteria are found in all kinds of habitats.
(ii) They are prokaryotic microorganisms.
(iii) They are unicellular.
(iv) Cell wall contains peptidoglycan.
(v) An organised nucleus in absent.
(vi) Extrachromosomal self replicating DNA segments called plasmids occur in most of the bacteria.
(vii) Mitochondria, plastids, Golgi apparatus,endoplasmic reticulum and other membrane covered cell organelles are absent.

Size

The size of bacterial cell ranges from 1-10 Jim in length and from 0.7-1.5 flm in width.

Shape

The bacteria possess the following forms
(i) Coccus (PI. cocci) bacteria are oval or spherical cells without flagella. The spheres occur as single cells (Monococcus), a pair of cells (Diplococcus), in groups of four cells (Tetracoccus), as chain of cells (Streptococcus) or in sheets (Staphylococcus).
A few cocci may also occur in cube-like arrangements of 8 or more cells (Sarcina).

(ii) Bacillus (PI. bacilli) bacteria are rod-shaped cells which many occur singly (Monobacillus), in pairs (Diplobacillus), in chains (Streptobacillus) or as a layer (suck) with many cells called Palisade bacillus.

(iii) Spirillum (PI. spirilla) bacteria are cells, which are twisted, like a screw. They occur as free single cells, e.g., Spirillum, Spirochaete, etc.

(iv) Vibrio are cells which are curved, C-shaped or comma-shaped, e.g., Vibrio cholerae.
Apart from these some other shapes of bacteria are also found

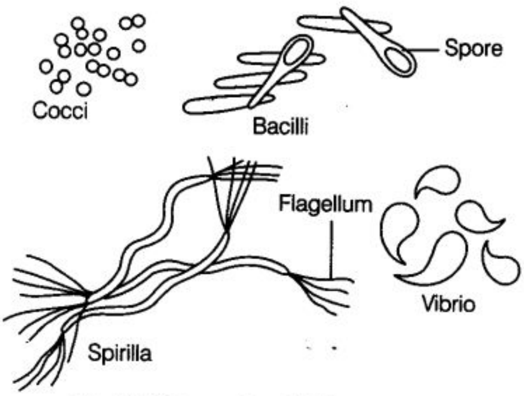


Fig 2.1 Bacteria of different shapes

Note:
Bacteria were discovered by Anton von Leeuwenhoek (1632-1723). He observed bacteria in 1675.
Louis Pasteur laid the foundation of Bacteriology by developing culture techniques.
Structure
A bacterial cell is covered by mucilage. It is differentiated into cell wall, plasma membrane, cytoplasm, nucleoid, plasmids, inclusion bodies, flagella, pilli and fimbriae. Membrane bound organelles are absent.
Details about the structure of bacteria (prokaryotes) will be studied later in chapter 8th of this book.

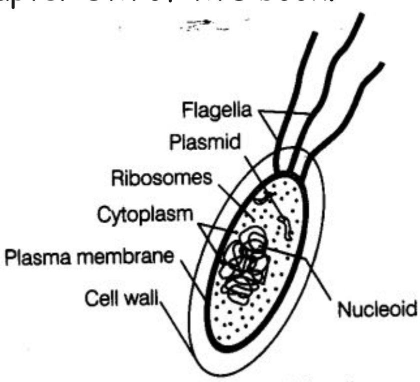


Fig 2.2 A bacterial cell

Nutrition

Bacteria show both autotrophic and heterotrophic mode of nutrition, i.e., mixotrophic.
On the basis of mode of nutrition, bacteria are of two types

i. Autotrophic Bacteria
These are of following two types

(a) Photosynthetic These bacteria have green – sunlight trapping pigment called bacterio chlorophyil.
These are found at the bottom of ponds and lotus. Bacterial photosynthesis does not release oxygen.
(b) Chemosynthetic These bacteria are able to synthesise organic food from inorganic raw materials with the help of energy derived from
• exergonic chemical reactions. Examples Nitrifying bacteria (Nitrosomonas), iron bacteria (Ferrobacillus ferroxidants), sulphur oxidising bacteria (Beggiatoa).

ii. Heterotrophic Bacteria
These bacteria obtain food from different sources. These may be of following types
(a) Saprophytes These are called decomposers, detrivores or transformers. These obtain food by decomposing dead-bodies, excreta of animals, dead plants and their parts.
(b) Parasites These are disease causing bacteria called as pathogens, e.g., Salmonelb typhimurium, which causes typhoid in human.
(c) Symbionts These bacteria live in mutually beneficial association with other organisms, e.g., Rhizobium and Bacillus, species form nodules in root of leguminous plants.

Reproduction
Bacteria reproduce by asexual and sexual (parasexual) processes.

i. Asexual Reproduction
Asexual reproduction occur by binary fission and endospore formation.
(a) Binary Fission It is a simple cell division in which bacterial cell divides in two parts. A constriction appears at the centre of the cell, deepens further and grows from margin to centre and finally two cells are produced.
(b) Endospore Formation Endospores are perennial structures which help in survival even during harsh environmental conditions, e.g., in Cbstridium and Bacillus. The endospore has many wall layers. It has heat resistant chemicals called sialic acid and dipicolinic acid.

ii. Sexual Reproduction
Sexual reproduction occurs by a parasexual process actually called genetic recombination.
The three methods involved are as follows

(a) Conjugation The male cell (donor cells) has fertility plasmid or F-factor, which connect itself to cell wall of female cells (receipient cells).
(b) Transformation The process was discovered by Griffith in 1928. It is a process where segments of DNA are transferred from one bacterial cell to another via the liquid medium.
(c) Transduction During this process, the segment of DNA are transferred from one bacterium to another by the viruses (bacteriophages).

Uses of Bacteria
Bacteria is useful in the following ways
(i) Bacteria are natural scavangers. They obtain their nutrition by decomposing dead bodies, dead plants and animal excreta.
(ii) These are used in the fermentation process for vinegar manufacturing, yogurt making, etc.
(iii) Some bacteria help in retting of jute and coconut plant fibres. The separated fibres are used in making ropes or gunny bags.
(iv) The genus Streptomyces has many species used to produce different antibiotics.
Some important antibiotics using various bacteria are neomycin, ... omycetin, streptomycin, gramicidin, bacitracin.
(v) Bacteria play important role in different steps of nitrogen cycle. Some important bacteria in nitrogen cycle, e.g, Clostridium, Azotobacter (soil bacteria), Rhizobium leguminosarum, Bacillus radicicola (in nodules), Nitrosomonas, Nitrosobacter, Pseudomonas etc.

Harmful Effects of Bacteria
Bacteria is harmful in the following ways
(i) Some saprophytic bacteria like Lactobacillus spoil milk and milk products.
(ii) Food poisoning occurs due to the production of toxins by some bacteria like Clostridium botulinum. They cause botulism, which can kill humans by respiratory paralysis.
(iii) Bacteria are responsible for various plant diseases like citrus canker in lemon leaves and fruits, soft rot in carrot plants, blight disease in rice plants, crown gall disease in apple trees and rose plants.
(iv) In humans, bacteria cause diseases like cholera (Vibrio cholerae), gastric ulcer (Heliobacter pylori), tuberculosis (Mycobacterium tuberculosis), sexually transmitted diseases like gonorrhoea(Neisseriagonorfhoeae), syphilis (Treponema

pallidum), etc.
(v) In animals like horse, cattle and sheep, anthrax disease is caused by Anthracis.

II. Archaebacteria

Archaebacteria (Archae-ancient; bacteria) are special since, they live in some of the most harsh habitats such as extreme salty areas (halophiles), hot springs (thermoacidophiles) and marshy areas (methanogens).
The characteristics of this domain are
(i) They are most primitive prokaryotes.
(ii) They are found in stressed environment, such as high salt content (Great salt lake, the dead sea), edge of the ocean, hot sulphur springs, volcanic walls, etc.
(iii) Their cell walls lack peptidoglycan. In most cases, the wall composed of non-cellulosic polysaccharides and some proteins. In some members, there is no cell wall. This feature of having different cell walls is responsible for their survival in extreme condition.
(iv) Most of the archaebacteria are chemoautotrophs.

Types of Archaebacteria
Archaebacteria are of following three types
i. Methanogens
These are stricdy anaerobes. They live anaerobically in gut of several ruminants such as cows, buffaloes, goat, etc. These bacteria help in fermentation of cellulose. They produce almost 65% of atmospheric methane.
Example Methanobacterium, Methanobacillus, Methanosarcina and Methanococcus.

ii. Halophiles
These are found in extreme saline environments like salt lakes, • salt marshes, salt pans, salt solutions, etc. They are mosdy anaerobes. They contain a chemical called halorhodopsin to pump in chlorides into the cell to prevent cellular dehydration. Halobacterium develops purple membrane having photoreceptor pigment bacteriorhodopsin. In light, it acts as a proton pump and helps in synthesise of ATP. The formation of ATP is a survival mechanism under anaerobic condition.
Examples Halobacterium and Halococcus.

iii. Thermoacidophiles
These archaebacteria can live in both extreme heat and acidic pH (around 2) environment. Under anaerobic conditions, these organisms oxidise sulphur to

sulphuric acid.

$2S + 2H_2O + 3O_2 \rightarrow 2H_2SO_4 + \text{Energy}$

Thermoacidophiles can survive in high temperature and low pH conditions because of

(a) Special branched chain lipids in cell membranes that reduce cell fluidity.
(b) Enzymes can work at low pH.
(c) Enzymes are resistant to high temperature coagulation. Examples Sulfobolus, Thermoplasma and Thermoproteus.

Importance of Archaebacteria

Archaebacteria can live in extreme environments, so they are useful in

(i) Modern biotechnology
(ii) Generation of biogas
(iii) Thermophilic enzymes
(iv) Biosensors
(v) Restriction enzymes, etc.

Differences between Eubacteria and Archaebacteria

Eubacteria	Archaebacteria
Cell wall is made up of peptidoglycans.	Peptidoglycan is absent in cell wall. It is made up of cellulosic carbohydrate.
Plasma membrane consists of phospholipids.	It is a single layer of branched chain lipids.
Genes are not interrupted by non-coding zones or introns.	Genes are interrupted by introns like eukaryotes.
Ribosomal proteins and RNA polymerase enzymes are very different from eukaryotes.	Ribosomal proteins and RNA polymerase are similar to eukaryotes.

III. Eubacteria

They are called 'true bacteria' and are characterised by the presence of a rigid cell walls, and if motile, have flagellum.

Cyanobacteria

Cyanobacteria, member of this group (blue-green algae) have many characters similar to bacteria. The examples of cyanobacteria are Nostoc, Oscillatoria, Spirulina, Rivularia, Anabaena, etc. They can survive in a wide variety of habitats, such as hot springs, sea water, polluted water, etc.

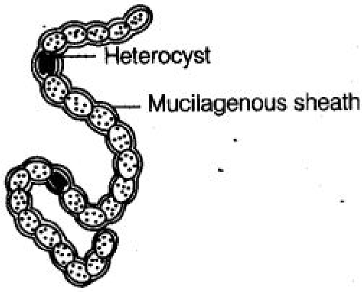


Fig. 2.3 A filamentous blue-green algae–*Nostoc*

Cyanobacteria have following three forms

(i) Unicellular as in Chrococcus.
(ii) Colonial as in Microcystis and Gloeocapsa.
(iii) Filamentous as in Nostoc, Oscillatoria and Anabaena.

Cell Structure

Cell has a definite firm and rigid cell wall surrounded by mucilaginous sheath. The cell wall is followed by plasma membrane made up of lipid and proteins. The membrane bound structures like true mitochondria, endoplasmic reticulum, Golgi bodies, etc., are absent.

The photosynthetic pigment present in the cell are chlorophyll, carotene, myxoxanthophyll, myxoxan- thin, etc. The nucleolus is absent and the nucleoid is not bound by nuclear membrane.
Some cyanobacteria (Nostoc, Anabaena, Scytonema, etc.) possess special type of cells called heterocysts to perform special functions. Heterocysts are the sites of nitrogen fixation.

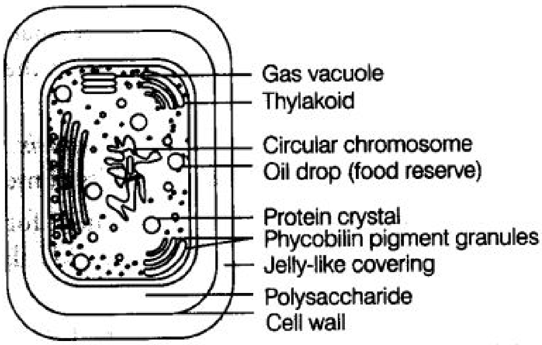


Fig. 2.4 Ultrastructure of a cyanobacterial cell

Nutrition

Cyanobacteria are mostly photoautotrophs. They contain chlorophyll-a and other photosynthetic pigments.

Reproduction

Cyanobacteria multiply asexually and vegetatively. Sexual reproduction does not occur.

The types of multiplication are

(i) Binary fission occurs in unicellular forms.

(ii) Fragmentation occurs in colonial and filamentous forms.

(iii) Conidia are asexually produced spores of fungi.

(iv) Endospores and exospores are non-reproductive structures.

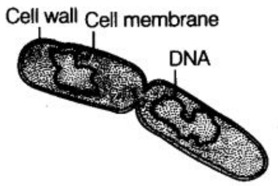


Fig 2.5 A dividing bacterium

Differences between Bacteria and Cyanobacteria

Bacteria	Cyanobacteria
Cell are smaller.	The cells are comparatively larger.
Cell wall is 1-2 layered.	The cell wall is four layered.
They may possess flagella.	They lack flagella.
They are both autotrophic and heterotrophic.	They are autotrophic.
Autotrophic bacteria contain bacteriochlorophyll.	They possess chlorophyll-*a* as found in eukaryotic autotrophs.
Photosynthesis is anoxygenic.	Photosynthesis is oxygenic.
The may be aerobic or anaerobic.	They are aerobic.
The reserve food is glycogen.	The reserve food is cyanophycean starch.

Uses of Cyanobacteria

Some uses of cyanobacteria are

(i) Some cyanobacteria have the ability to fix atmospheric nitrogen. The green manuring by farmers is done on this basis to enrich the soil with nitrogenous fertilisers.

(ii) Cyanobacteria like Anabaena, Tolypothrix, etc., help in prevention of soil erosion and its conservation.

(iii) Spirulina is a protein rich supplement for humans. It is a fast growing cyanobacteria. It is also known as Single Cell Protein (SCP).

(iv) Cyanobacteria like Anabaena and Aulosira prevent mosquito larvae to grow in surroundings.

Harmful Effects of Cyanobacteria

Some harmful effects of cyanobacteria are

(i) Cyanobacteria discolour the walls and roofs of buildings, movements and statues.
(ii) Oscillatoria causes asthma and gastrointestinal problems by releasing its toxins.
(iii) Growth of Oscillatoria in water bodies shows pollution by organic matter.
(iv) Excessive growth of cyanobacteria form water blooms, which decreases oxygen level in water causing death of aquatic animals.

IV. Mycoplasma

Mycoplasma are organisms that completely lack a cell wall.
They were discovered by Roux (1898) in pleural fluid of cattle suffering from pleuropneumonia. The organisms are often called MLOs (Mycoplasma Like Organisms) or PPLOs (Pleuropneumonia Like Organisms).

The characteristic features of mycoplasma are

(i) Their size ranges from 0.1-0.5 pm and have organised nucleus, plastids, mitochondria and other organelles are absent.
(ii) DNA is naked (because of absence of histones) and ribosomes (of 70S type).
(iii) Mycoplasma possess heterotrophic nutrition. Examples Mycoplasma gallisepticum, M. laidlawii. They cause pleuropneumonia in domestic animals, mycoplasmal urethritis in humans.

Kingdom-Protista

Kingdom—Protista includes all single-celled eukaryotes but, the boundries of this kingdom are not well defined. It was first proposed by Ernst Haeckel (1866). Physiologically kingdom-Protista acts as a connecting link between the kingdom-Monera and the complex multicellular kingdom-Fungi, Plantae and Animalia. Kingdom-protista includes the following categories such as dinoflagellates, chrysophytes, euglenoids, slime moulds and protozoans.

The general characteristic features of kingdom-Protista are given below

(i) These are mostly aquatic organisms. Some protists also live in the bodies of animals as parasites.
(ii) The cells are eukaryotic. These contain membrane bound cell organelles like mitochondria, Golgi complex, endoplasmic reticulum, 80S ribosomes, etc.

(iii) Locomotion may either occur by Pseudopodia (Amoeba, Euglypha), Cilia (Parameciuni),
Wriggling (sporozoans, non-flagellates) and Mucilage propulsion (some protists like diatoms).
Diatoms do not have any organelles for locomotion.

(iv) Protists shows various modes of nutrition such as
(a) Photosynthetic (holophytic) Dinoflagella- tes, diatoms and euglenoids.
(b) Halozoic (zootrophic) Protozoans like Amoeba and Paramecium.
(c) Saprobic (saprotrophic) In slime moulds.
(d) Parasitic Trypanosoma, Giardia, Plasmodium, Entamoeba.
(e) Mixotrophic InEuglena.
(f) Symbiotic In zooflagellates like Trichonympha and Lophomonas.
(g) Pinocytosis In Amoeba to absorb soluble organic substances.
(v) Most of the protists are aerobic. However, some protists that live at the bottom of aquatic habitats can respire anaerobically.
(vi) Protists reproduce asexually and sexually by a process involving cell fusion and zygote formation.

Protista Kingdom and its Phylum

The major groups of Protista are
(a) Protistan algae (photosynthetic protists)
(b) Slime moulds (consumer-decomposer protists).
(c) Protozoan protists.

Photosynthetic Protists
These chrysophytes form the main part of phytoplankton. These include chrysophytes, dinoflagellates and euglenoids.
1. Chrysophytes
This group includes diatoms and golden algae (desmids).

i. Diatoms

(a) Diatoms occur in all aquatic and moist terrestrial habitats and are also known as chief producer in the ocean.
(b) They pile up at the bottom of water reservoirs and form big heaps called diatomaceous earth.
(c) They are microscopic unicellular organisms of
different shapes, such as circles, semicircles, triangular, spindle-shaped, boat-shaped, etc.
(d) The body wall of the diatoms is made up of cellulose impregnated with glass like silica. The cell wall has two overlapping halves like a sapbox called shell or ffustule, i.e., a lid and a lower half fitted together.
(e) Diatoms are variously coloured, do not passess flagella except in the reproductive state.
(f) Each cell has a large central vacuole.
(g) Chloroplast are yellowish brown to greenish brown. They contain chlorophyll-^ and c. They contain fucoxanthin that provides brownish ting.
(h) Food is reserved in the form of oils and leucosin (polysaccharide).
(i) The diatoms mostly reproduce asexually by binary fission. Sexual reproduction varies from isogamy to oogamy. Examples Navicula, Amphipleura , Triceratium and Cymbella.

Economic Importance of Diatoms

* Diatoms are economically important in the following ways –
* Diatoms are very important photosynthesizers.
* Diatomite deposits are often accompanied by petroleum fields.
* These are used as a cleaning agent in tooth pastes and metal polishes and are used in filtration of oil and syrups.
* Diatoms are used as insulation material in refrigerators boilers and furnaces. These are also used to make sound-proof rooms.
* Diatoms are also very good pollution indicators.

ii. Golden Algae (Desmids)

These are unicellular green algae. Their cell walls have distinct halves. Sexual reproduction occurs by ‘conjugation’ (similar to Spirogyra). They are usually found in freshwater and acts as an indicators of polluted water.

2. Dinoflagellates

These are mainly marine and photosynthetic organism. There are about 1,000

species of photosynthetic protists.
The general characteristic features of dinoflagellates are listed below
(i) These are important phytoplanktons. Most of them are marine but some occur in freshwater.
(ii) They appear yellow, green, brown, blue or red depending on the main pigments present in their cells.
(iii) The cell wall in dinoflagellates, if present is composed of number of plates made up of cellulose.
Some dinoflagellates like Gonyautax and Gymnodinium grow in large number in sea and make the water look red and form 'red tide'.
Toxins released by such large numbers may even kill other aquatic animals.

(iv) The cells usually possess two flagella which are of different types (heterokont). One flagellum is transverse arising from the anterior part. The other flagellum arises in the vertical furrow. Both these flagella beat in different directions.

(v) The nucleus is bigger in size, named as mesokaryon. Chromosomes do not have histone and RNA.
(vi) The cells possess an osmoregulatory organelle called pusule, which superficially looks like contractile vacuole.
(vii) Dinoflagellates reproduce asexually through cell division or by the formation of zoospores and cysts.
(viii) Varieties of eye spots' occur in dinoflagellates. Some of them are like ocelli.
(ix) Reserve food is stored in the form of starch and oils, e.g., Gonyaulax, Ceratium, Noctiluca, Peridinium and Gymnodinium, etc.

3. Euglenoids
Euglenoids live in fresh aquatic habitats and damp soils.
The characteristic features of euglenoids are described below
(i) They are unicellular flagellate protists.
(ii) Body is covered by thin and flexible pellicle. It lacks ceflulosic cell wall.
(iii) Euglenoids have two flagella, usually one long and one short.
(iv) They perform creeping movements by expansion and contraction of their body. This phenomenon is called metaboly.
(v) Nutrition is holophytic, saprobic or holozoic. This mode of nutrition is called mixotrophic.
(vi) The photosynthetic pigments include chlorophyll-^ and b.

(vii) Reserve food is carbohydrate in the form of paramylon or paramylum bodies.
(viii) Euglenoids reproduce by longitudinal binary fission under favourable conditions. The palmella stage is found during unfavourable conditions. Examples Euglena, Perenema, Eutreptia, Phacus, etc.

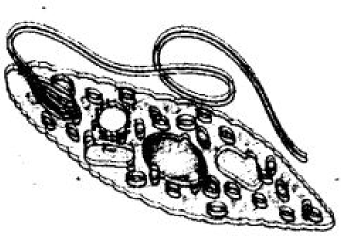


Fig 2.6 *Euglena*

Euglena is considered as plant as well as animal. It is also called as plant animal. Plant and animal features are * Plant Features Chloroplasts and chlorophyll are present has holophytic nutrition.
* Animal Features Presence of pellicle which is not made of cellulose. Contractile vacuole is present. Longitudinal binary fission.

Note:
* Euglenozoa is a diverse clade that includes predatory heterotrophs, photosynthetic autotrophs and pathogenic parasites.
* The main feature that distinguishes protists in this clade is the presence of a spiral or crystalline rod of unknown function inside the flagella.

Consumer-Decomposer Protists (Slime Moulds)
They possess the characters of both animals and fungi.

Slime Moulds
Slime moulds are saprophytic protists. Anton De Bary (1887) related them to animals and called them as Mycetozoa. These are also named as fungus animals because they share the common characters of both animals and are known as protistian jungi, and due to their protistian nature.
The generalfeatures of slime moulds are discussed here (t) Slime moulds are acellular and cellular types, about 600 species of slime moulds are reported by biologists out of which 27 species are known from India.
(ii) They are found in moist terrestrial places rich in decaying organic food.
(iii) The body of slime moulds is covered with mucilage having gelatinous consistency, they do not have chlorophyll.

(iv) They are surrounded by plasma membrane. However, the spores have the ceflulosic cell walls.
(v) They show phagotropic or saprotrophic nutrition.
(vi) Both sexual and asexual modes of reproduction occur.
(vii) They are like Protozoa in their amoeboid plasmodial stage and similar to true fungi in spore formation.

(viii) Acellular slime moulds (plasmodial slime moulds) are commonly found on dead and decaying plant matter. The cellular slime moulds occur in all humus-containing upper layer of damp soil. When the food supply is shorter or conditions are not favourable, the amoeboid cells form aggregate without any fusion.
This aggregated mass is called pseudoplasmodium. The examples of cellular slime moulds are dictyostelium and polysphondylium.

(ix) Plasmodium is the free-living thalloid body of the acellular slime moulds. It is wall-less mass of multinucleate protoplasm covered by slime layer. During unfavourable conditions, the Plasmodium differentiates and forms fruiting bodies bearing spores at their tips. WTiile during favourable conditions, Plasmodium can spread over several feet.

(x) Slime moulds are beneficial as they cause the decomposition of organic matter in the soil.

Protozoan Protists

Include unicellular protists with animal like behaviour.
They were first studied by Leeuwenhoek (1677).
Protozoan protists may be aquatic, terrestrial or parasites.
They can cause several diseases in humans and animals.
General characteristics of protozoans are described below
(i) They are microscopic small unicellular and colourless organism with different shapes.
(ii) Locomotion occurs with the help of finger-like pseudopodia, flagella or hairy cilia.
(iii) All protozoans are heterotrophs and live as predators or parasites.
(iv) Respiration occurs through the general surface of the body.
(v) Reproduction occurs by binary fission, multiple fission or budding. Sexual reproduction occurs by syngamy and conjugation.

There are four major groups of protozoans

1. Amoeboid Protozoans

These organisms live in freshwater, seawater or moist soil.
Examples Amoeba, Entamoeba, Radiolarians, Pelomyxa, Foraminiferans and Heliozoans.

General features of this group are following

(i) They move and capture their prey by putting out pseudopodia (false feet) as in Amoeba (as mouth is absent).
(ii) The body is without periplast. It may be naked or have a calcareous shell.
(iii) Flagella are present in some developmental stages. They also develop when food become scarce.
(iv) Nutrition is holozoic.
(v) Asexual reproduction occurs by binary fission, multiple fission, spores and budding and sexual reproduction occurs by syngamy.

2. Flagellated Protozoans

The members of this group are either free-living or parasitic. Examples Giardia, Trypanosoma, Leishmania, Trichonympha and Trichomonas.
General features of this group are following
(i) They have flagella for locomotion as their name suggests.
(ii) They may be aquatic, free-living, parasitic, commensals or symbiotic.
(iii) The body is enclosed by a firm pellicle.
(iv) Nutrition is holozoic, saprobic and parasitic.
(v) Asexual reproduction is by binary fission.
(vi) Sexual reproduction is observed in some forms only.
(vii) Various species of these protozoans causes diseases in humans. For examples,
* Trypanosoma (sleeping sickness)
* Leishmania (kala-azar, dum-dum fever)
* Giardia (giardiasis)
* Trichomonas (leucorrhoea).

3. Ciliated Protozoans

These are aquatic, actively moving organisms because of the presence of thousands of cilia.
Examples Paramecium, Opalina, Vorticella, Podophyra, Balantidium, etc.
Generalfeatures of this group are following
(i) Many ciliates live as free-living individual in fresh % and marine water (Paramecium).

(ii) A large number of cilia present on whole body surface.Cilia are used to capture food and for locomotion.
(iii) Nutrition is holozoic except in some parasitic forms.
(iv) The body is covered with flexible pellicle.
(v) There are definite regions for ingestion and egestion.
(vi) Ciliates have a larger macronucleus and smaller micronudeus.
(vii) They have small ejectable trichocysts for defense.
(viii) Osmoregulation occurs by contractile vacuoles.
(ix) Asexual reproduction occurs by transverse binary fission or budding. Cyst formation also occurs during unfavourable condition.
(x) Sexual reproduction by means of conjugation.

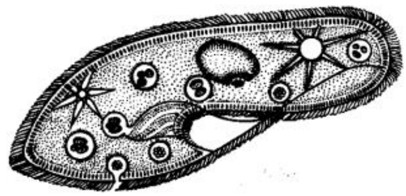


Fig 2.7 *Paramecium*

Sporozoan Protozoans

This group includes organisms that have an infections spore-like stage in their life cycle.

Examples Plasmodium, Monocystis, Eimeria.

General features of this group are following

(i) All sporozoans are endoparasites and pathogenic.
(ii) Locomotory organs are absent.
(iii) Nutrition is parasitic (absorptive).
(iv) Body is covered with an elastic pellicle or cuticle and contractile vacuoles are absent.
(v) A sexual reproduction occurs through multiple fission and sexual reproduction by syngamy.
(vi) Life cycle may include two different hosts, e.g., Plasmodium requires two hosts (digenetic), female Anopheles mosquito and human beings. It is responsible for causing malaria, in humans.

Biological Classification Class 5 MCQs Questions with Answers

Question 1.
The two kingdom Classification was given by
(a) c.linnaeus

(b) john ray
(c) huxley
(d) whittaker
Answer
Answer: (c) huxley

Question 2.
Choose the correct pair.
(a) Parasitic fungi – feeds on plants and animals
(b) Saprotrophic fungi – feeds on dead and decaying organic matter
(c) Symbiotic fungi – mycorrhiza
(d) All of the above are true

Answer
Answer: (d) All of the above are true
Explanation:
Saprotrophic fungi feeds on dead and decaying organic matter.
Parasitic fungi feeds on animals and plants.
Symbiotic fungi are of two types mycorrhiza and lichens.
Mycorrhiza – the fungus is in close association with roots of higher plants.
Lichens – fungi is in close relationship with algae.
Question 3.
Which of the following is used in biochemical and genetic work?
(a) Claviceps
(b) Aspergillus
(c) Neurospora
(d) Mucor
Answer
Answer: (c) Neurospora
Explanation:
Neurospora is used in biochemical and genetic work, it belongs to class Ascomycetes.
Question 4.
If a scientist has to names a similar species he should study the
(a) Holotype
(b) syntype
(c) mesotype
(d) isotype

Answer
Answer: (d) isotype
Question 5.
Which of the following is not a viral disease?
(a) AIDS
(b) Herpes
(c) Tuberculosis
(d) Smallpox
Answer
Answer: (c) Tuberculosis
Explanation:
AIDS, herpes and smallpox are viral diseases.
Tuberclosis is a bacterial disease.
Question 6.
Choose the correct match.
(a) Photosynthetic autotrophs – Nutrient recycling
(b) Chemosynthetic autotrophs – Nitrogen fixation
(c) Heterotrophic bacteria – Production of antibiotics
(d) Mycoplasma – Production of curd

Answer
Answer: (c) Heterotrophic bacteria – Production of antibiotics
Explanation:
Photosynthetic autotrophs helps in fixing atmospheric nitrogen.
Chemosynthetic autotrophs helps in nutrient recycling.
Heterotrophic bacteria helps in making curd, production of antibiotics, etc.

Question 7.
The scientist who created the group protista for both unicellular plants and animals is
(a) haecke
(b) pasteur
(c) lister
(d) koch

Answer
Answer: (a) haecke

Question 8.
Binomial nomenclature was given by
(a) huxley
(b) ray
(c) darwin
(d) linnaeus

Answer
Answer: (d) linnaeus

Question 9.
Which of the following is an indicator of air pollution?
(a) Mycorrhiza
(b) Agaricus
(c) Lichens
(d) Common mushrooms

Answer
Answer: (c) Lichens

Explanation:
Lichens are the indicators of air pollution.
Lichens are the association between fungi and algae. They do not grow in polluted areas.

Question 10.
The natural system of Classification is based on
(a) morphology
(b) evolutionary trend
(c) anatomy
(d) all of the above
Answer
Answer: (d) all of the above
Question 11.
Potato spindle tuber disease is caused by
(a) Phycobionts
(b) Virus

(c) Bacteria
(d) Viroids
Answer
Answer: (d) Viroids
Explanation:
In 1971, Diener discovered a new infectious agents called Viroids that was smaller than viruses.
These viroids causes potato spindle tuber disease.
Question 12.
Quinine is obtained from
(a) Puccinia
(b) Neurospora
(c) Gonyaulax
(d) Cinchona
Answer
Answer: (a) Puccinia
Explanation:
Quinine is obtained from Cinchona officinalis.
Question 13.
According to five-kingdom classification, which of the following does not contain nuclear membrane?
(a) Protista
(b) Monera
(c) Fungi
(d) Animalia
Answer
Answer: (b) Monera
Explanation:
According to five kingdom classification, Monera does not contain nuclear membrane.
Question 14.
Two organisms of the same class but different families will be kept under the same
(a) genera
(b) species
(c) order
(d) family
Answer
Answer: (c) order

Question 15.
Bacteria that live in hot springs are called
(a) Halophiles
(b) Thermoacidophiles
(c) Methanogens
(d) None of the above
Answer
Answer: (b) Thermoacidophiles
Explanation:
The bacteria that live in hot springs are called thermoacidophiles.
Bacteria that live in salty areas are called halophiles.
Bacteria that live in marshy areas are called methanogens.
Question 16.
Which amongst kingdom animalia has become recently extinct?
(a) snow leopard
(b) indian macaque
(c) cheetah
(d) tiger
Answer
Answer: (c) cheetah
Question 17.
Red tides in sea appear due to
(a) Euglena
(b) Chrysophytes
(c) Dinoflagellates
(d) Diatoms
Answer
Answer: (c) Dinoflagellates
Explanation:
Red tides in sea appear is due to red dinoflagellates.
Gonyaulax undergoes rapid multiplication and makes the sea apear red.
Question 18.
The asexual spores are not found, vegetative reproduction occurs by fragmentation and sexual organs are absent. Identify the class of fungi.
(a) Phycomycetes
(b) Ascomycetes
(c) Basidiomycetes
(d) Deuteromycetes

Answer
Answer: (c) Basidiomycetes
Explanation:
In basidiomycete asexual spores are not found and vegetative reproduction occurs by fragmentation.
Sex organs are absent in this class of fungi.
Question 19.
Match the columns:
1. Basidiomycetes – A. Agaricus
2. Ascomycetes – B. Albugo
3. Phycomycetes – C. Trichoderma
4. Deuteromycetes – D. Saccharomyces
(a) 1-D, 2-A, 3-B, 4-C
(b) 1-A, 2-D, 3-B, 4-C
(c) 1-A, 2-B, 3-D, 4-C
(d) 1-C, 2-D, 3-A, 4-B
Answer
Answer: (b) 1-A, 2-D, 3-B, 4-C
Question 20.
Trypanosoma causes
(a) Dysentry
(b) Mumps
(c) Sleeping sickness
(d) Cholera
Answer
Answer: (c) Sleeping sickness
Explanation:
Trypanosoma causes sleeping sickness.
NCERT Solutions For Class 11 Biology Biological Classification

Topics and Subtopics in **NCERT Solutions for Class 11 Biology Chapter 2 Biological Classification:**

Section Name	**Topic Name**
2	Biological Classification
2.1	Kingdom Monera
2.2	Kingdom Protista
2.3	Kingdom Fungi
2.4	Kingdom Plantae

2.5	Kingdom Animalia
2.6	Viruses, Viroids and Lichens
2.7	Summary

NCRT TEXT BOOK QUESTIONS SOLVED

1.Discuss how classification systems have undergone several changes over a period of time?

Soln. Biological classification is the scientific procedure of arranging organisms in a hierarchical series of groups and sub-groups on the basis of their similarities and dissimilarities. Scientists have proposed different systems of classification which have undergone several changes from time to time.

Earlier Aristotle proposed artificial system of classification, which divided animals and plants on basis of habitat. E.g., Aquatic (fish, whale), terrestrial (e.g., reptiles, cattle) and aerial (e.g., bat, birds). Then, natural system of classification was based on morphology^ anatomy, physiology, reproduction, ontogeny, cytochemistry, etc. After natural system, organisms were classified on basis of evolutionary relationships called phyloge¬netic system. It is based on cytotaxonomy, chemotaxOnomy, numerical taxonomy and cladistic taxonomy.

2.State two economically important uses of:
(a) heterotrophic bacteria
(b) archaebacteria

Soln. (a) Heterotrophic bacteria: They include saprotrophic, symbiotic and parasitic bacteria. They act as natural scavengers as they dispose off the dead bodies, organic wastes, release raw materials for reutilisation. They also help in sewage disposal, manure production etc. Symbiotic bacteria help in nitrogen fixation. Some bacteria arq employed in the production of a number of industrial products like lactic
acid, curd, cheese, butter, vinegar etc. Some bacteria are used in preparation of serum, vaccines, vitamins, enzymes, antibiotics etc. e.g., Pseudomonas, Xanthomonas, etc.

(b) Archaebacteria : Archaebacteria are employed in the production of gobar gas from dung and sewage and in ruminants, they cause fermentation of cellulose.

3.What is the nature of cell-wall in diatoms?

Soln. The cell walls of diatoms are called frustules. The cell wall is chiefly composed of cellulose impregnated with glass-like silica. It is composed of two overlapping halves (or theca) that fit together like two parts of a soap box or petri dish. The upper half (lid) is called epitheca and the lower half (case) is called hypotheca. The outer covering possesses very fine markings, pits, pores and ridges. The siliceous frustules of diatoms do not decay easily. They pile up at the bottom of water reservoirs and form big heaps called diatomite or diatomaceous earth. It may extend for several hundred metres in certain areas from where the same can be mined.

4.Find out what do the terms 'algal bloom' and 'red tides' signify.

Soln. The rapid increase in populations of algae and other phytoplanktons, in particular cyanobacteria, in water bodies rich in organic matter is called algal bloom. The density of the organisms may be such that it may prevent light from passing to lower depths in the water body. Algal blooms are caused by an increase in levels of nitrate, a mineral ion essential for algal and bacterial growth.

The source of increased nitrate may be from agricultural fertilizers, which are leached – into water systems from the land, or sewage effluent.

Red tides are caused by a sudden, often toxic proliferation of marine phytoplankton, notably dinoflagellates, that colour the sea red, brown, or yellowish due to the high concentration of the photosynthetic accessory pigments. Some dinoflagellates, such as Gonyaulax, produce potent toxins, which may kill fish and invertebrates outright or accumulate in the food chain, posing a hazard to humans eating shellfish and other seafood. These phytoplanktonic blooms may be related to nutrient-rich inputs from the land, or upwelling oceanic waters, and are initiated by the activation of cyst-like forms lying on the sea bed.

5.How are viroids different from viruses?

Soln. Viroids are the smallest known agent of infectious diseases that contain small single-stranded RNA molecule. They lack capsid and have no proteins associated with them. Viroids infect only plants. Whereas, viruses have genetic material surrounded by a protective coat of protein or lipoprotein. The genetic material of viruses are of 4 types – double-stranded DNA, double-stranded RNA, single-stranded DNA, single-stranded RNA. They infect both plants and animals.

6.Describe briefly the four major groups of protozoa.

Soln. All protozoans are heterotrophs and live as predators or. parasites. They are be-lieved to be primitive relatives of animals. They are classified into four groups on the basis of locomotory organelles.

(i) Amoeboid protozoans : These organisms live in fresh water, sea water or moist

soil. They move and capture their prey by developing pseudopodia (false feet) as in Amoeba. Some of them such as Entamoeba are parasites.
(ii)Flagellated protozoans : The members of this group are either free-living or parasitic. They have flagella for locomotion. The parasitic forms cause diseases such as sleeping sickness e.g., Trypanosoma.
(iii)Ciliated protozoans : These are aquatic, actively moving organisms because of the presence of thousands of cilia. They have a cavity (gullet) that opens to the outside ' of the cell surface. The coordinated movement of rows of cilia causes the water laden with food to be steered into the gullet e.g., Paramecium. ~
(iv)Sporozoans: This includes diverse parasitic organisms that have an infectious spore¬like stage in their life cycle. Locomotory organs are absent. The most notorious N . is Plasmodium (malarial parasite) which causes malaria which has a staggering effect on human population.

7.Plants are autotrophic. Can you think of some plants that are partially heterotrophic ?

Soln. Some insectivorous plants like Drosera, Nepenthes, Utricularia are partially heterotrophic plant. These plants are deficient in nitrogen content but are otherwise autotrophic. They, trap various insects to obtain nitrogen from them. Rest, the food i.e., carbohydrate is manufactured by themselves.

8.What do the terms phycobiont and mycobiont signify?

Soln. A lichen is structurally organised entity consisting of the permanent association of a fungus and an alga. The fungal component of a lichen is called mycobiont and the algal component is called phycobiont. Both mycobiont and phycobiont are associated in symbiotic union in which the fungus is predominant and alga is subordinate partner. – ; Fungus provides the structural covering that protects alga from unfavourable conditions, i.e., drought, heat, etc. It also traps moisture from the atmosphere and anchors the lichen to a rock, tree bark, leaves and other similar supports. The alga prepares organic food by the process of photosynthesis from carbon dioxide. If the algal component is cyanobacteria (blue-green alga), they fix atmospheric nitrogen in addition to preparation of food.

9.Organise a discussion in your class on the topic – 'Are viruses living or non-living'?

Soln. Viruses are regarded as intermediate between non-living entities and living organisms. It is very difficult to ascertain whether they are living or non-living. Some . characters of viruses suggest their non-living nature whereas many other characters suggest their living nature.

They resemble non-living objects in –

(i) Lacking protoplast.

(ii)Ability to get crystallised.

(iii)Inability to live independent of living cell.

(iv)High specific gravity which is found
.only in non-living objects.

(v)Absence of respiration.

(vi)Absence of energy storing system.

(vii)Absence of growth and division. Instead different parts are synthesized separately.

Viruses resemble living beings in –

(i)Being formed of organic macromolecules which occur only in living beings.

(ii)Presence of genetic material.

(iii)Ability to multiply or reproduce although only inside living cell.

(iv)Occurrence of mutations.

(v) Occurrence of enzyme transcriptase in most viruses.

(vi)Some viruses like Pox virus contains vitamins like riboflavin and biotin.

(vii)Infectivity and host specificity.

(viii)Viruses are 'killed' by autoclaving and ultraviolet rays.

(ix)They breed true to their type. Even variations are inheritable.

(x) They take over biosynthetic machinery of the host cell and produce chemicals required for their multiplication.

(xi)Viruses are responsible for a number of infectious' diseases like common cold, epidemic influenza, chicken pox.

10.What are the characteristic features of Euglenoids?

Soln. The euglenoid flagellates are the most interesting organisms having a mixture of animal and plant characteristics. The characteristic features are:

(i) They are unicellular flagellates.

(ii)These protists lack a definite cellulose cell wall. Instead the cells are covered by
a thin membrane known as pellicle. The pellicle is composed of protein, lipid and carbohydrates.
(iii)One or two flagella which help these protists in active swimming are present. If two flagella are present, then one is long and other is short. They are tinsel – shaped i.e., with two longitudinal rows of fine hairs. Each flagellum has its own basal granule. The two flagella join with each other at a swelling, called paraflagellar body and finally only one long flagellum emerges out through the cytostome.
(iv)Cell at the anterior end possesses an eccentric mouth or cytostome which leads into a flask-shaped cavity viz. gullet or cytopharynx. Gullet opens into a large basal reservoir.
(v) At one end of the reservoir, the cytoplasm contains an orange red stigma (eye spot). The eye spot is a curved plate with orange-red granules and contains red pigment astaxanthin. Both paraflagellar body and eye spot act as photoreceptors.
(vi)Just below the reservoir is found a contractile vacuole having many feeding canals. The contractile vacuole takes part in osmoregulation. It expands and pumps its fluid contents in the reservoir.
(vii)The mode of nutrition in euglenoids is holophytic or photoautotrophic. Some euglenoids show mixotrophic nutrition (both holophytic as well as saprobic mode).
(viii)Cytoplasm is differentiated into ectoplasm and endoplasm. Nucleus is large and occurs roughly in middle. The envelope and nucleolus persist during cell division.
(ix)Each chloroplast is composed of a granular matrix traversed by 10-45 dense bands and is covered by 3-membraned envelope. They contain the photo¬synthetic pigments-chlorophyll – n, b. They store carbohydrates as paramylon bodies, scattered throughout the cytoplasm.
(x) Asexual reproduction occurs by longitudinal binary fission. The flagellum is duplicated before cell division.
(xi)Under unfavourable condition the euglenoids form cysts to perennate the dry period.
(xii)Sexual reproduction is not observed.

11.Give a brief account of viruses with respect to their structure and nature of genetic material. Also name four common viral diseases.

Soln. Virus (L. poisonous fluid) is a group of ultramicroscopic, non-cellular, highly infectious agents that multiply only intracellularly- inside the living host cells without involving growth and division. Outside the host cells, they are inert particles. They are nucleoproteins having one or more nucleic acid molecule, either DNA or RNA, encased in a protective coat of protein or lipoprotein. A virus consist of two parts – nucleoid (genome) and capsid. An envelope and few enzymes are present in some cases,

(i) Nucleoid : The nucleic acid present in the virus is called nucleoid and it represents viral chromosome. It is made up of a single molecule of nucleic acid. It may be linear
or circular and nucleic acid can be DNA or RNA. It is the infective part of virus which utilizes the metabolic machinery of the host cell for synthesis and assembly of viral components.

(ii)Capsid : It is a protein covering around genetic material. Capsid have protein subunits called capsomeres. Capsid protects nucleoid from damage from physical and chemical agents. ,

(iii)Envelope : It is the outer loose covering present in certain viruses like animal viruses (e.g., HIV) but rarely present in plant and bacterial viruses and made of protein of viral origin and, lipid and carbohydrate of host. Outgrowths called spikes may be present. Envelope proteins have subunits called peplomers. A virus without envelope is naked virus.

(iv)Enzymes : Rarely, lysozymes are found in bacteriophages. Reverse transcriptase enzyme (catalyses RNA to DNA synthesis) is found in some RNA viruses like HIV.
Some common viral diseases are – influenza, polio, measles, chickenpox, hepatitis, AIDS, bird flu, SARS (Severe Acute Respiratory Syndrome) etc.

12.Give a comparative account of the classes of Kingdom Fungi under the following:
(i) mode of nutrition (ii) mode of reproduction

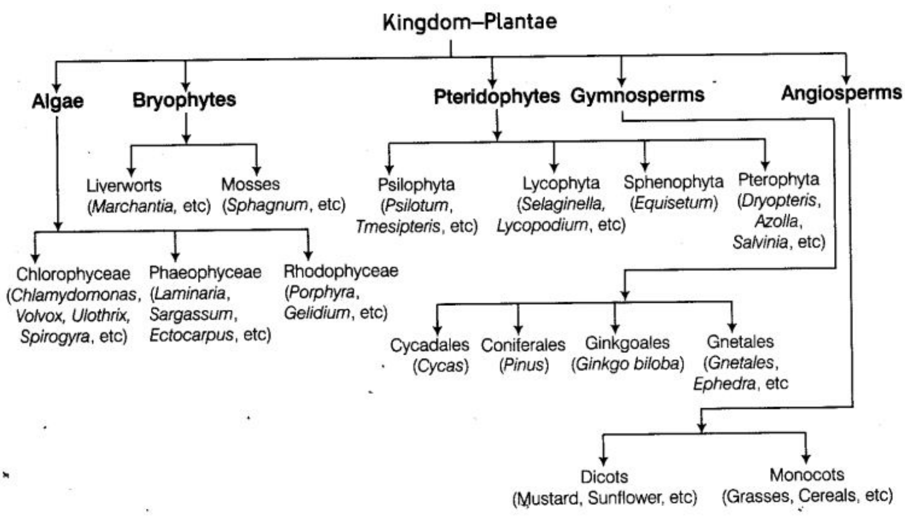
Soln.

Class of fungi	Mode of nutrition	Mode of reproduction
Phycomycetes (Includes oomycetes & zygomycetes)	Oomycetes are mostly parasitic (obtain their nourishment from the protoplasm of living plants or animals *e.g.*, *Phytophthora infestans*).	In oomycetes asexual reproduction is by zoospores (aquatic form), aplanospore (terrestrial form). Sexual reproduction may be isogamous or oogamous, sexual fusion is gametangial contact type. Male sex organ is antheridium and female sex organ is oogonium. Plasmogamy is followed by karyogamy and meiosis(oospore formation).
	Zygomycetes are mostly saprophytes (absorb food from dead or decaying organic matters *e.g.*, *Rhizopus*), parasitic (*Absidia cornealis*), some are coprophilous (fungi which grow on dung *e.g.*, *Mucor*).	In zygomycetes asexual reproduction occurs by thin walled non motile sporangiospores inside sporangia. Sexual reproduction takes place by gametangial copulation (two identical gametangia) know as conjugation. Sexual reproduction forms diploid zygospore.
Ascomycetes (Sac fungi)	Most are terrestrial and occur as saprophytes (*e.g.*, *Aspergillus*), parasitic (*Claviceps*). Some grow in deciduous forests on humus rich soil (*Morchella*).	Asexual reproduction by conidia or conidiospores (*Aspergillus*), budding (*Saccharomyces*), fission(*Schizosaccharomyces*). Sexual reproduction by gametic copulation *e.g.*, yeast), gametangial contact (*e.g.*, *Pyronema*), spermatization (*Ascobolus*), somatogamy (*Peziza*). Sexual reproduction takes place in three stages plasmogamy (fusion of protoplast), karyogamy (fusion of nucleus) and meiosis. Ascospores are formed in ascus. Generally each ascus consists of eight ascospores. Fructification are known as, ascocarp (cleistothecium, *e.g.*, *Penicilium*, perithecium *e.g.*, *Neurospora*, and apothecium *e.g.*, *Peziza*).
Basidiomycetes	Mostly saprophytes (*Agaricus*), on humus, bark, decaying wood etc. Some are obligate parasites (*e.g.*, rusts, powdery mildews, which live entirely on the living protoplasm of their hosts and can never grow on dead tissue), some are facultative saprophytes (some smuts, which are usually parasitic in their mode of life but later may pass their mode of life as saprophytes).	The asexual spores are generally not found, but vegetative reproduction by fragmentation is common. The sex organs are absent, but plasmogamy is brought about by fusion of two vegetative or somatic cells of different strains or genotypes. The resultant structure is dikaryotic which ultimately gives rise to basidium. Karyogamy and meiosis take place in the basidium producing four basidiospores. The basidiospores are exogenously produced on the basidium (*pl.*: basidia). The basidia are arranged in fruiting bodies called basidiocarps.
Deuteromycetes	Mostly parasitic.	Asexual reproduction by conidia and some other spores. Sexual reproduction is either absent or yet to be discovered.

Plant Kingdom Class 5 Notes Biology Chapter 3

Basis of Classification and Algae, Bryophytes & Pteridophytes

Our understanding of the plant kingdom has changed over time. Fungi and members of the Monera and Protista having cell walls have not been separated form Plantae, the earlier classifications kept them in the same kingdom. The kingdom-Plantae has been described under algae, bryophytes, pteridophytes, gymnosperms and angiosperms. The overview of this classification is demonstrated here in the flowchart.



Types of Classification System
These includes artificial system, natural system and phylogenetic system of classification.
The various systems used in classification ofiplants are being discussed here

Plant Kingdom 0777 023 444

1. Artificial System of Classification

This system is based on comparison of one or a few superficial characteristics, which are helpful in easy identification of organisms. This system remained in use for about two thousand years.
Aristotle is known as father of Zoology.

Carolus Linnaeus is known as father of Taxonomy.
Advantages
Advantages of artificial system as below
(i) Artificial system is easy to remember as only one or few characters are used.
(ii) The traits used are of interest to humans.

Disadvantages
Disadvantages of artificial system are given below
(i) This system use only few superficial characters (i.e., habits, numbers, colours and shapes of leaves, etc) which leads to many organisms grouped together,
(ii) They considered mainly the vegetative characters or the androecium characters as given by linnaeus.
(iii) It does not demonstrate natural and phylogenetic relationships.
(iv) This gave equal weightage to vegetative and reproductive/sexual characters this is not acceptable, as vegetative characters are more easily influenced by the environmental factors.
(v) They sparated the closely related species.

2. Natural System of Classification

It is also known as phenetic system of classification. The natural system of classification is based on natural affinities among the organisms. It considers both external and internal features like structure, anatomy, embryology and phytochemistry.

Advantages
Advantages of natural system are given below
(i) Only related organisms are kept in a group.
(ii) Unrelated organisms are kept in separate groups.
(iii) It shows natural relationships among the organisms.
(iv) It shows possible origin of different taxa.

Disadvantages

Disadvantages of natural system are given below

(i) There is more emphasis given on natural character.

(ii) In this system several related families are separated and unrelated families are put together.

(iii) Evolutionary basis is neglected.

3. Phylogenetic System of Classification

The phylogenetic system of classification indicates the evolutionary as well as genetic relationships among organisms. This system is based on fossil records of biochemical, anatomical, morphological, physiological, embryological and genetical. The system was initiated by Engler and PrantI (1887-1899) in Die Naturalichen Pflanzefamilien. In phylogenetic system, flowering plants are placed in ascending series related to complexity of floral morphology. The phylogenetic system of classification are mainly the rearrangement of taxonomic characters in addition to the phylogenetic information.

Advantages

Advantages of phylogenetic system are given below

(i) Families and order in this system are of small size.

(ii) This system is in conformation with the modern views of phylogeny.

(iii) They use information from various sources to solve problems of classification. Such informations become more important in the absence of supporting fossil evidences.

Disadvantages

Disadvantages of phylogenetic system are given below

(i) This is not helpful in plant identification.

(ii) The classification is outdated as the habit is used as . main basis of classification.

Types of Taxonomies

For the suitability in studies various categorizations has been done in taxonomy.

The important taxonomies are as follows

1. Numerical Taxonomy

It is carried out by quantitative assessment of similarities and differences in order to make objective assessments. It is now easily carried out using computers based on all observable characteristics. Number and codes are assigned to all the characters and the data are then processed. In this way, each character is given equal importance and at the same time hundreds of characters can be considered.

2. Cytotaxonomy

Cytotaxonomy is based on cytological information like chromosome number, structure, behaviour and type of chromosomes. For example,

(i) Chromosome number is constant for a species, e.g., 46 in man, 48 in apes and potato, 20 in maize, 16 in onion and 8 in Drosophila.

(ii) Behavior of chromosomes was used by taxonomists during pairing and banding patterns to understand the relationships between species, e.g, Origin of humans from apes, origin of wheat, etc.

3. Chemotaxonomy

It is the system based on the evidences from chemical constituents (enzymes, hormones, proteins, amino acids, etc.), some specific chemicals (usually secondary metabolites) and the chemical nature of proteins have been utilised to establish similarities and relationships. For example, the presence of raphides has been found to be common in 35 families of plants.

Algae

Algae are chlorophyll-bearing, simple, thalloid, autotrophic and largely aquatic (both freshwater and marine) organisms.

The important salient features of algae are given below

Habitat

These are found in both freshwater and marine habitats. Some algal forms are also found in moist habitats like wet rocks and soil, tree trunks, etc. Some of them are also found in close association with fungi (lichen) and animals {e.g., on sloth bear).

Thallus Organisation

The plant body (thallus) is without differentiation. The basic form and size of algae is highly variable, and ranges from filamentous {e.g., Ulothrixand Spirogyrd) to colonial {e.g., Volvox). These are attached on the substratum with the help of holdfast.

Structure of Algal Cell

It has an eukaryotic plant cell structure. The cytoplasm contains membrane bound chloroplast, mitochondria, ER, Golgi bodies and other cell organelles. The cell wall contains cellulose. The nucleus contains nuclear membrane.

Food Material

Algae have main food reserve as starch. In brown algae, mannitol and laminarin are the main reserve food material, whereas in red algae floridean starch is the reserve food material.

Reproduction

The algae reproduces vegetatively, asexually and sexually.

i. Vegetative Reproduction

It occurs by fragmentation, tubers, stolons, adventitious branches, etc. Each fragment gets develop into a thallus.

ii. Asexual Reproduction

It occurs by a number of accessory spores, such as zoospores aplanospores, akinetes, carpospores, etc.

The most common being the zoospores, which are flagellated. The cells which produce spores are called sporangia. The sporangia may be the vegetative cells (e.g. in Chlamydomonas and Ulothrix) or modified vegetative cells (e.g. in Vaucheria).

iii. Sexual Reproduction

It occurs by fusion of two gametes.

On the basis of morphology of reproductive cells, sexual reproduction is of two types

(a) Isogamy In this method, two morphologically similar gametes fuse to form a zygote, e.g., Spirogyra.

(b) Heterogamy In this process, fusion occurs between morphologically as well as physiologically different gametes. It is of two types

Anisogamy It is the fusion of structurally dissimilar gametes, which differ in size and – behaviour. Male gamete is more active and female gamete is less active and bigger in size, e.g., Some species of Chlamydomonas.

* Oogamy In this process, the male gamete is motile, active, small and without reserve food.

The female gamete is bigger, passive, non-motile and laden with food, e.g., Volvox, Fucus.

Embryo and Life Cycle

An embryo stage is not present. Life cycle is haplontic, diplontic, diplohaplontic, haplohaplontic, etc. An alternation of generation occurs in diplohaplontic life cycle.
Economic Importance of Algae
(i) Algae are responsible for carrying out about a half of the total carbon dioxide fixation on earth by the process of photosynthesis.
(ii) Some forms of marine brown and red algae produce large amount of hydrocolloids. These are algin (brown algae) and carrageenan (red algae) which have many commercial uses.
(Hi) The algae Gelidium and Gracilaria are used to produce agar, which is used in preparation of ice creams and jellies.
(iv) Some protein rich algae, like Chlorella and Spirullina are used as food supplements by sailors and space travellers.
(v) About 70 species of marine alga are used as food, e.g., Porphyra, Laminaria and Sargassum.

Classification of Algae

Algae are divided into various classes based on pigmentation, stored food and flagellation. The three main classes are
Chlorophyceae, Phaeophyceae and Rhodophyceae.
i.Class-Chlorophyceae (Green Algae)
The members of Chlorophyceae are commonly called green algae.
There are about 7000 species in this class. The reserve food material is starch.

The characteristic features of Chlorophyceae are discussed below
(a) Habitat These are mostly marine forms, only some are freshwater. Chlorella can tolerate moderately warm waters. Snow dweling forms are called cryophytes, e.g., Chlamydomonas nivalis, Scotiella, etc.
(b) Cell Organisation .These are unicellular, colonial, coenocytic and multicellular forms. Cell walls contain cellulose (inner layer) and pectose (outer layer) in most of the green algae. The chloroplasts may be discoid, plate-like, reticulate, cup-shaped, spiral or ribbon shaped.
The chloroplasts contain pigments. Most of the members have one or more storage bodies called pyrenoids located in” the chloroplasts. Pyrenoids contain protein besides starch. Some algae may store food in the form of oil droplets also.

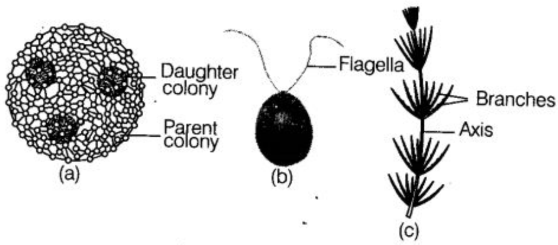


Fig 3.2 Green algae (a) *Volvox* (b) *Chlamydomonas* (c) *Chara*

(c) Thallus Unicellular green algae can- be flagellate, (Chlamydomonas), unicellular, non-flagellate (Chlorella).
Acetabularia (umbrella plant) has unicell upto 10 cm long with distinction of nucleus containing rhizoid, elongated stalk and umbrella like cap.
A colony for fixed number of individual unicells (Volvox) is called coenobium.
Coenocytic or siphonaceaus thallus occurs in Caulerpa. Unbranched filamentous thallus in Ulothrix and Spirogyra, Cladophora, heterotrichous in Stigeoclonium and parenchymatous in Ulva.

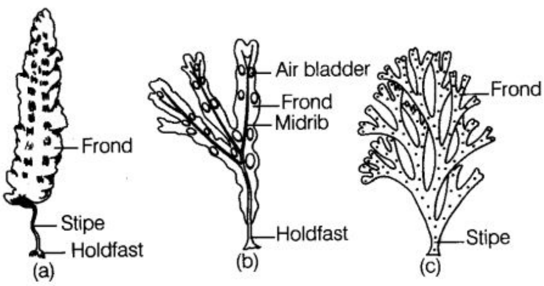


Fig 3.3 Brown algae (a) *Laminaria* (b) *Fucus* (c) *Dictyota*

(d) Reproduction The members of Chlorophyceae reproduce vegetatively, asexually and sexually by various methods.
* Vegetative reproduction occurs through cell division (unicellular forms), fragmentation, stolons, tubers, storage cells, etc.
* Asexual reproduction occurs by zoospores, aplanospores, hypnospores, akinetes and daughters colonies.
* Sexual reproduction may be isogamous, anisogamous or oogamous.
(e) Life Cycle It can be haplontic, diplontic and diplohaplontic. In haplontic life cycle, there is a single somatic phase, which is haploid. Diploid stage is represented by a single cell or zygote, e.g., In Spirogyra.

ii. Class-Phaeophyceae (Brovin Algae)
The members of Phaeophyceae are fucoxanthin and phycocolloid rich multicellular eukaryotic algae. Its common members are seaweeds called kelps. This class is comprised of about 2000 species.

(a) Habitat Brown algae are mostly marine. These are found mostly in colder seas or during cold seasons in tropical regions.
(b) Size They range from simple branched, filamentous forms (Ectocarpus) to profusely branched forms as represented by kelps. These represent largest algae. The largest kelps are Macrocystis (40-100m) and Nereocystis (20-30 m).

(c) Cell Organisation All members are multicellular. Cell wall is composed of cellulose, pectose and phycocolloids. The cellulosic wall of vegetative cells is usually covered on the outside by a gelatinous coating of algin.

(d) Thallus It is heterotrichous filament with both prostrate and upright branches (Ectocarpus). The parenchymatous structure is found in higher forms. The plant body of large forms often differentiated into holdfast (with which it usually attaches to the substratum) a stalk called the stipe and lamina (frond), which is photosynthetic. Conducting tubes or trumpet hyphae are present in larger brown algae or kelps. They help in conduction of food materials.

(e) Photosynthetic Pigments and Colour These include chlorophyll-4, c and carotenoids. They ranges in colour from olive green to various shades of brown depending upon the amount of the xanthophyll pigment, fucoxanthin present in them.

(f) Food Reserve It remains in the form of complex carbohydrates such as laminarin or mannitol.
(g) Flagellation These contain heterokont flagellation with one smooth (whiplash) and one tinsel flagella.
(h) Reproduction Vegetative reproduction occurs through fragmentation (e.g., Sargassum), adventitious branches and stolons (e.g, Dictyota). Asexual reproduction by biflagellate zoospores, which are pear-shaped having two unequal laterally attached flagella.

Sexual reproduction is performed by isogamy, anisogamy and oogamy. Union of gametes may take place in water or within the oogonium (oogamons species). The gametes are pyriform (pear-shaped) and have two laterally attached flagella.
(i) Life Cycle Isomorphic alternation of generation is found in some brown algae, e.g, Ectocarpus, Dictyota. In many brown algae, the diploid generation or phase is

dominant. The haploid phase is either microscopic or represented by gametes only (e.g., Fucus).

Economic Importance of Pheophyceae
* The brown algae that are used as food are Laminaria, Nerocystis, Macrocystis, Alaria, etc.
* Some brown algae like Fucus, Sargassam, Laminaria, Macrocystis are important fodder for catde.
* Brown algae are collected from sea shores and used as manure. They improve mineral content of soils.
* Alginic acid is a phycocolloid obtained from a number of brown algae such as Alaria, Macrocystis, Ascophyllum, Laminaria. It is used as emulsifier, thickener, gelating agent in toothpastes, shaving creams, ice-creams, emulsion paints, shampoo, cosmetics, etc.
* Fucus and Laminaria are rich in iodine.

iii. Class-Rhodophyceae (Red Alqae)
The members of Rhodophyceae are commonly called red algae because of the predominance of the red pigment,i.e., r-phycoerythrin in their body.
(a) Habitat Most of the red algae are marine with greater concentrations found in the warmer areas. They are found in both well lighted regions close to the surface of water and also at great depths in oceans where relatively little light penetrates.

(b) Thallus The red thalli of most of the algae are multicellular. Some of them have complex body organisation like Asterocystis is pseudofilamentous, Porphyridium is unicellular, Porphyra has parenchymatous sheets, Cbondrus is ribbon like, Gelidium is a multicellular sea weed.

(c) Cell Wall The cell wall contains cellulose, pectic compounds and certain mucopolysaccharides called phycocolloids, such as agar, carrageenin, etc. In many algae, cell wall contains pits.

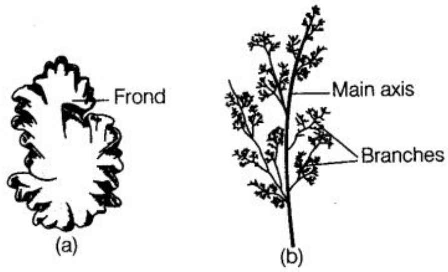


Fig 3.4 Red algae (a) *Porphyra* (b) *Polysiphonia*

(d) Photosynthetic Pigments These include chloro¬phyll-4, carotenes, xanthophylls and phycobilins. Phycobilins are water soluble and are of two types, i.e., red-coloured phycoerythrin and blue-coloured phycocyanin.

(e) Reserve Food It is floridean starch similar in constitution to glycogen and amylopectin. if) Reproduction Vegetative reproduction occurs by fragmentation, regeneration of hold fast and gemmae. Asexual reproduction occurs by non-motile spores (carpospores, monospores, tetraspores and neutral spores).

(f) Sexual reproduction occurs by non-motile gametes and is oogamous type. The male sex organs is called spermatogonium or antheridium. The male produced is non-flagellated, called as spermatium. The female sex organ is called carpogonium. After fertilisation, a new structure called carposporophyte is produced. It remains attached to the parent alga.

(g) Life Cycle Life cycle has two or more phases such as haplohaplontic, haplohaplohaplontic, diplodiplohaplontic, etc.

Economic Importance of Red Algae

* The red algae like Porphyra, Chondrus, Rhodymenia, Centerella and Bostrychia are used as food in various parts of the world.
* Agar yielding algae are called aerophytes, such as Gelidium, Gracilaria, Ceramium, Gelidiella, etc.
* Alga like Rhodymenia are used as fodder for cattle.
* Carrageenin a phycocolloid obtained from red algae like Chondrus and Gigartina is used in preparations of emulsions for ice cream, chocolates, sauces, toothpastes, cosmetics, etc. It is also used in clearing liqueurs and finishing leather, etc.
* Funori an adhesive phycocolloid is obtained from red alga Gloiopeltis. It is used in sizing textiles, paper and as glue.
* Some algae like Corallina, Polysiphonia have medicinal properties.

Bryophytes

Bryophytes include the various mosses and liverworts. These are non-vascular embryophytes, characterised by the presence of. an independent gametophyte and parasitic sporophyte.

Habitat
Bryophytes commonly grow in -moist, shaded areas in hills. These are also called amphibians of the plant kingdom because, these can live in soil but are * dependent on water for sexual reproduction.

Rhizoids
These are attached to the substratum by unicellular or multicellular rhizoids.

Sex Organs
The main plant body produces gametes, hence it is called gametophyte. The sex organs in bryophytes are multicellular, the male sex organs in bryophytes is called antheridium (which produces biflagellate antherozoids) and the flask-shaped female sex organ is called archegonium (produces a single egg).

Reproduction
It is of sexual type reproduction. The antherozoids are released into water where they come in contact with archegonium.

Fertilisation
It occurs inside the archegonium. The egg secretes a chemical which attracts spermatozoids. Sperms require a thin film of water for swimming and reaching the dehisced archegonium. One sperm fuses with an egg and produces a diploid zygote. Zygotes do not undergo reduction division immediately instead, they produce a multicellular body called sporophyte.

Dependent Sporopbvrc The sporophyte is not free-living but attached to the photosynthetic gametophyte deriving nourishment from it. Some cells of the sporophyte undergo reduction division (meiosis) to produce haploid spores (which germinate to produce gametophyte).
The sporophyte of bryophytes is called sporogonium because it is mainly dependent and meant for producing spores.

Life Cycle
Bryophytes have heteromorphic or heterologous alternation of generation. The gametophyte may be produced directly or first from a juvenile stage called protonema.

Economic Importance
Bryophytes in general are of little economic importance. But, several species have some uses.
(i) Some mosses provide food for herbaceous mammals, birds and other animals.
(ii) Species of Sphagnum (a moss), provides peat that
have long been used as fuel. It has the capacity to hold water as packing material for transshipment of living material.
(iii) Mosses along with lichens are the first organisms to colonise rocks. Hence, these help in biological succession. They decompose rocks making the substrate suitable for the growth of higher plants.
(iv) Mosses from dense mats on the soil, they reduce the impact of falling rain and prevent soil erosion.
(v) Marchantia has medicinal properties to cure lungs and liver infections. It also has antitumour properties.
Bryophytes do not attain great heights. They may range of 0.4 to 70 cm and have thalloid body.

The reasons may be following
(i) Root is absent.
(ii) Vascular tissues are not present.
(iii) Cuticle is not present on the plant body.
(iv) Absence of mechanical tissue.
(v) Male gametes need to swim upto the interior of dehisced archegonia.

Types of Bryophytes
The bryophytes are generally classified into two main groups
i. Liverworts
Liverworts (Hepaticopsida) usually grow in moist, shady places such as banks of streams, marshy ground, damp soil, bark of trees and deep in the woods.
(a) Thallus The plant body of a liverwort is thalloid, e.g, Marchantia,. The thallus is dorsoventral and closely appressed to the substrate. The leafy members have tiny leaf like appendages in two rows on the stem like structure.

(b) Rhizoids These are unicellular. These may be of two types in some liverworts, i.e. smooth walled and tuberculate.

(c) Reproduction It may occur both by asexual and sexual means.
• Asexual Reproduction It occurs by fragmentation of thalli or by the formation of specialised structures called gemmae (sing, gemma). Gemmae are green, multicellular, asexual buds which develop in small receptacles called gemma cups located on the thalli. The gemmae become detached from the parent body and germinate, forming new individuals.

• Sexual Reproduction During this male and female sex organs are produced either on the same or on different thalli. The sporophyte is differentiated into a foot, seta and capsule. After meiosis, spores are produced within the capsule.

• These spores germinate to form free-living gametophytes, e.g., Riccia, Marchantia, Pellia, Porella, etc.

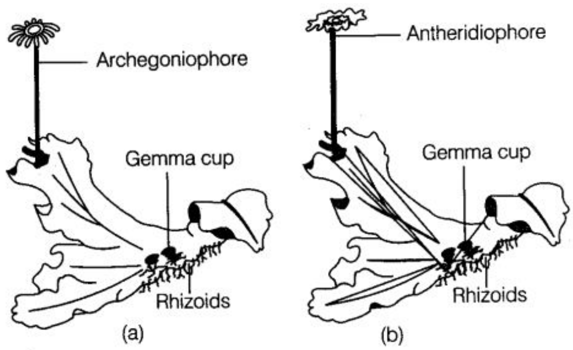


Fig 3.5 A liverwort (*Marchantia*) (a) Female thallus (b) Male thallus

ii. Mosses

Mosses (Bryopsida) grow in dense mats over moist shady places, especially during rains. Some mosses grow in desert bogs and streams.
(a) Plant Body The predominant stage of the life cycle of a moss is the gametophyte which consists of two stages the first stage is the protonema stage which develops directly from a spore. It is a creeping, green, branched and frequently filamentous stage; the second stage is the leafy stage which develops from the secondary protonema as a lateral bud. They consist of upright, slender axes bearing spirally arranged leaves. This stage bears sex cells.

(b) Rhizoids These are long, multicellular branched structures with oblique septa. They take part in fixation and absorption of water. However, surface conduction through capillarity is an important mechanism of water supply to aerial parts.

(c) Reproduction This can occur both by vegetative and sexual means.
* Vegetative Reproduction It occurs by fragmentation and by budding in the secondary protonema from exposed rhizoids and other parts (like gemmae, buds and tubers).

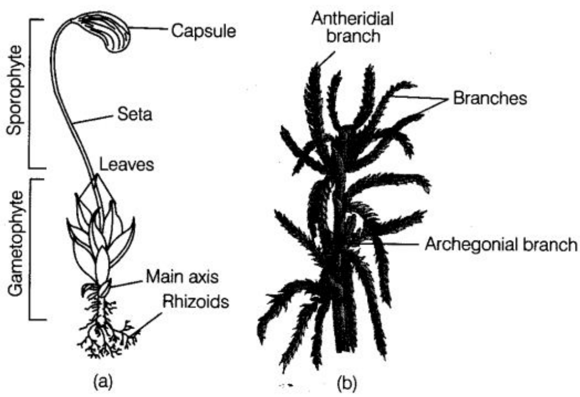


Fig 3.6 Mosses (a) *Funaria*, gametophyte and sporophyte
(b) *Sphagnum* gametophyte

Sexual Reproduction Sex organs, antheridia and archegonia are produced at the apex of the leafy surface. Male organs appear cup-shaped, while female organs are bud-like. After fertilisation, the zygote develops into a sporophyte, consisting of foot, seta and capsule (containing spores).

(d) Sporophyte The sporophyte in mosses is more elaborate than that in liverworts. Spores are formed after meiosis. The mosses have an elaborate mechanism of spore dispersal, e.g., Funaria, Polytrichum and Sphagnum.

Differences between Liverworts and Mosses

Liverworts	Mosses
They are dorsiventral.	They have radial symmetry.
Plants are thalloid or foliose.	Mosses are foliose.
Midribs is not present in leaves.	Leaves have unbranched midrib.
Rhizoids are unicellular and unbranched.	Rhizoids are multicellular and branched.
Plants bear scales.	Scales are absent in plants.
A conducting strand is absent.	A conducting strand is commonly present.
Sporophyte is differentiated in foot, seta and capsule.	It is not differentiated in foot, seta and capsule.
Capsule often possesses elaters.	Elaters are absent.
Dehiscence occurs through elaters.	Peristome perform these functions.
A protonema stage is absent.	A juvenile protonema stage is present.

Pteridophytes

Pteridophytes are primitive seedless vascular plants also called cryptogams. These have conspicuous sporophytic plant body, inconspicuous independent gametophytes with antheridia and partially embedded archegonia having 4-rowed necks.

The term Pteridophyte was coined by Haeckel (1866). There are about 13000 species of pteridophytes have been reported. They were perhaps the first land plants evolved during ordovician (450-500 million years ago) period.
The characteristic features of pteridophytes are as follow

Habitat
The pteridophytes are found in cool, damp shady places though some may flourish well in sandy-soil conditions.
Some members like Azolla, Salvinia, Marsilea species.

Plant Body
The size varies from a fraction of centimeter (e.g, Azolla) to 20 m in tree ferns (e.g, Angiopteris). The main plant body is a sporophyte which is differentiated into

true root, stem and leaves. These organs possess well differentiated vascular tissues. The leaves are small (microphyllus) as in Selaginella or large (macrophylls) as in ferns.

Vascular Tissues

These are xylem and phloem present throughout the body. Xylem consists of tracheids and phloem is made up of sieve cells and albuminous cells.

Sporophylls

The sporophytes bear sporangia that are subtended by leaf like appendages called sporophylls. In some cases sporophylls may form distinct compact structure called strobili or cones (Selaginella and Equisetuni). The sporangia produce spores by meiosis in spore mother cells.

Spores

The spores germinate to give rise to inconspicuous, small but multicellular free-living, mostly photosynthetic thalloid gametophytes called prothallus. In majority of the pteridophytes, all the spores are of similar kinds; such plants are called homosporous. Genera like Selaginella and Salvinia which produce two kinds of spores, macro (large) and micro (small) spores; such plants are called heterosporous.

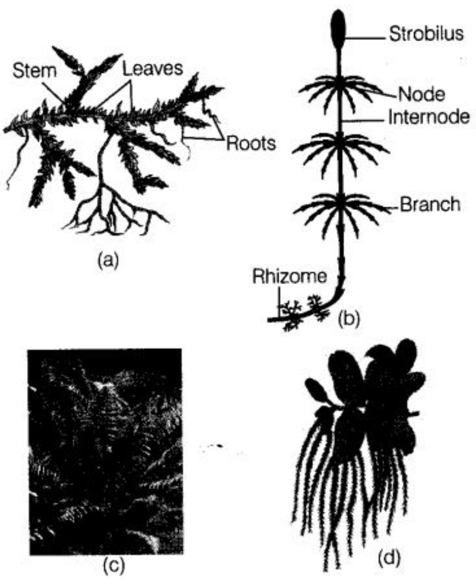


Fig 3.7 (a) *Selaginella*
(b) *Equisetum* (c) Fern (d) *Salvinia*

Gametophyte
The thalloid gametophyte or prothallus require cool, damp, shady places to grow. The megaspores and microspores germinate and give rise to female and male gametophytes respectively. The female gametophytes in these plants is retained on the parent sporophytes for viable periods. In most ferns, prothallus is green and autotrophic. In heterosporous ferns, the female gametophyte depends on food stored by the megaspore.

Sex Organs
The gametophytes bear male sex organs called antheridia and female sex organs called archegonia. Antheridium is sessile and surrounded by a single layered jacket. Archegonium is flask-shaped. It is partially embedded.

Fertilisation
Water is required for transfer of antherozoids. The male gametes released from the antheridia and reach to the mouth of archegonium. Fusion of male gamete with the egg present in the archegonium result in the formation of zygote. Zygote therefore, produces a multicellular, well differentiated sporophyte, which is the dominant phase of the pteridophytes.

Embryo
Fertilisation produces a zygote that undergoes division to produce embryo. The development of the zygote into young embryo takes place within the female gametophyte.
* This event is a precursor of the seed habit and considered as an important step in evolution, e.g., Dryopteris, Selaginella, Adiantum, Equisetum and Salvinia.

Economic Importance of Pteridophytes
(i) Pteridophytes are a good source of food for animals. For example, sporocarps of Marsilea is edible. Angiopteris and Alsophila have starchy pith eaten by natives of Australia.
(ii) Ferns protect soil from erosion by providing a good cover on the hill slopes and other fragile places.
(iii) Equisetum stems have rough surfaces. They are used in scrubbing and polishing.
(iv) Azolla a water fern has a symbiotic association with nitrogen fixing cyanobacterium Anabaena azollae. It is cultured in paddy fields to harbour nitrogen fixing bacterium. Thus, act as a biofertiliser.
(v) Rhizomes and petioles of Dryopteris are used to produce anthelmintic drug.

Roots of Adiantum can cure throat infections. Lycopodium is used in treatment of rheumatism and disorders of lungs and kidneys.
(vi) Ferns are also grown as ornamental plants for their graceful plant body.

Classification of Pteridophytes
The pteridophytes are further classified into four classes
(i) Psilopsida (Psilotum)
(ii) Lycopsida (Selaginella and Lycopodium)
(iii) Sphenopsida (Equisetum)
(iv) Pteropsida (Dryopteris, Pteris and Adiantum)

Differences between Bryophytes and Pteridophytes

Bryophytes	Pteridophytes
The main plant body is gametophyte.	It is sporophyte.
These are non-vascular plants.	These are vascular plants.
Sporophyte is parasitic over gametophyte.	Sporophyte is independent of gametophyte.
Plant body can be thallus or foliose.	It is differentiated into stem, leaves and roots.
True stems and leaves are not present.	It has true stems and leaves.
Roots are absent, rhizoids are present.	Roots are present.
Sex organs are stalked.	Sex organs are sessile.
The wall of archegonial neck is 5-6 rowed.	The wall of archegonial neck is 4-rowed.

2. Gymnosperms, Angiosperms and Plant Life Cycles

Gymnosperms
The gymnosperms (Gymnos = naked; sperma = seeds) are plants in which the ovules are not enclosed by any ovary wall and remain exposed, both before and after fertilisation. These are small groups of seed plants which are represented by only 900 living species. Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. They remain within the sporangia retained on the sporophytes.

Habitat
These plants are mostly found in colder parts of northern hemisphere, where they

form extensive forests. A number of gymnosperms are now, known as ornamentals, e.g., Ginkgo, Thuja, Araucaria, etc.

Morphology

Gymnosperms include, medium-sized trees or tall trees and shrubs. The giant red wood tree Sequoia is one of the forest tree upto 100 m. Species of Gnetum are woody climbers. The smallest gymnosperm is Zamia pygmaea which reaches a height of 25 cm. Many of the gymnosperms live for more than 4000 years, e.g, Pine (Pinus), redwood {Sequoia).

External Features

The plant body is sporophyte and differentiated into root, stem and leaves.

Plant Body

Tap roots are present for proper anchorage to heavy plant. Roots in some genera have fungal association in the form of mycorrhiza {Pinus), while in some others {Cycas) small specialised roots called coralloid roots are associated with N2-fixing cyanobacteria such as Anabaena, Nostoc, etc.
The stems are branched {Pinus, Cedrus) or unbranched {Cycas). The leaves may be simple or compound.

Archegonia

The megaspore mother cell thus, undergo meiotic division forming four megaspores. Out of which one is enclosed within the megasporangium (nucellus) and develops into a multicellular female gametophyte, bearing two or more archegonia of female sex organs.
The multicellular female gametophyte is also retained within megasporangium.

Fertilisation

Air current required for transport of male gametes. The male gametes are carried to the archegonia, i.e., gamete in the ovule by means o'f a tube called pollen tube and discharge their contents near the mouth of the archegonia. This is called siphonogamy.

Seeds

Following fertilisation, zygote develops into an embryo and the ovules into seeds. The seeds contain food laden tissue called endosperm. It lies naked or exposed.

Endosperm provides nourishment for growth of seedling at the time of seed germination.
Examples Cycas, Pinus, Ginkgo, Ephedra, Gnetum, Vaucheria, Cedrus, Abies, etc.

Differences between Microsporophyll and Megasporophyll

Microsporophyll	Megasporophyll
It bears microsporangia.	It bears megasporangia.
It contains numerous microspores.	It usually contains one megaspore.
Microspores are released.	Megaspore are retains inside the megasporangium.

Classification of Gymnosperms

Gymnospermsfurther include three main classes Cycadopsida (cycads), Coniferopsida (conifers) and Gnetopsida (Gnetum).

Differences between Male Gametophyte of Pteridophyte and Gymnosperms

Male Gametophyte of Pteridophyte Male Gametophyte of Gymnosperms
A distinct male gametophyte may not be present. A distinct male gametophyte is present.
It contains an antheridium. Antheridium is not present.
Male gametes are flagellate. Male gametes can be flagellate or non-flagellate.
Male gametes reach female gametes by swimming in water. Male gamete reach the female gamete through a pollen tube.

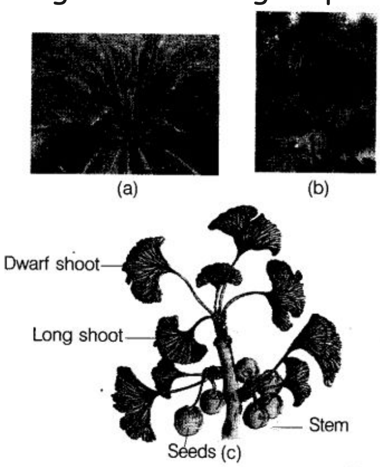


Fig. 3.8 Gymnosperms : (a) *Cycas* (b) *Pinus* (c) *Ginkgo*

Economic Importance of Gymnosperms

(i) Seeds of Pinus gerardiana (chilgoza) are used a food after roasting. Some other edible gymnosperms plant part are endosperm of Ginkgo, seed kernel of some Cycas and Gnetum, sago grains from stems of Cycas, etc.
(ii) Gymnosperms provide softwood for construction, plywood and paper industry.

(iii) Branches of gymnosperm trees are used as fuel food.
Saw dust of conifers is used in making plastics and linoleum.
Resin is a semifluid secreted by special tubes of a number of conifers. It helps in sealing female cones after pollination, scale leaves around leaf bases and apical buds. Resin is distilled to obtain turpentine and resin. Turpentine is used for . thinning paints, varnishes, etc., and resin is used
for sealing joints, wheel green, preparation of writing paper, oil clothes, etc.

(iv) Ephedrine an antibiotic is obtained from Ephedra. It is used for curing respiratory problems and asthma. Taxol is an anticancer drug obtained from Taxus.

Angiosperms
Angiosperms are seed bearing plants or flowering plants. Unlike gymnosperms where the ovules are naked, in angiosperms the sporophyll are organised into flowers and the seeds are produced inside fruits. There are about 250000 species of angiosperms in the nature. They evolved about 130-160 million years ago.

Habitat
Angiosperm are found in wide range of habitats, from the land to up to 6000 m in Himalayas or Antarctica and Tundra, dry hot deserts, cold deserts, tropics, fresh water up to 60°C, underground, over other plants as parasites, saprophyte, etc. Zostera is a marine angiosperm.

Plant Body
These plant are sporophytic, in the form of herbs, shrubs, trees, climber creepers, etc. The smallest angiosperm is water plant Wolffia and tallest is Eucalyptus regnans (100 mand above). Primary root develops from radicle. It forms tap root system. In many angiosperms roots develop from places other than radicle, these are adventitious roots. Stem develops from plumule.

Leaves
These are simple or compound. The leaves bear axillary buds which can grow into stem branches.

Vascular Tissues
Angiosperms have vessels in xylem. Phloem contains sieve tubes and companion cells in regard to gymnosperms which do not have companion cells.

Flowers

Flowers are the reproductive structures formed by the union of one or both types of sporophylls (microsporophylls or stamens and megasporophylls or carpels).

Microsporophylls or Male Sex Organs

Stamens are considered as the male sex organs of a flower. Each stamen has two main parts, i.e., a slender filament with an anther (at the tip). An anther contains four microsporangia where microspore mother cells become differentiated to form four microspores, each developing into a pollen grain.

Megasporophylls or Female Sex Organs

Carpel or pistil is called the female sex organ of the flower. Each carpel has three parts {i.e., an ovary, style and stigma). A megaspore mother cell is differentiated in the nucellus and undergoes meiosis, ultimately one functional megaspore gets enlarged and forms the female gametophyte known as embryo-sac.

Each cell of an embryo sac is haploid:

Embryo Sac

Each embryosac contains a three celled eg® apparatus consisting I of one egg cell and two synergids, three antipodal cells (at the i opposite end) and two polar nuclei (in the central cell). The polar : nuclei eventually fuses and forms diploid secondary nucleus.

Pollination

Pollen grains after dispersal from the anthers are carried by various ways such as wind, water or by various other agencies to the stigma of the pistil.

Fertilisation and Development of a Seed

Each pollen grain germinates on the stigma forming a pollen tube that carries two male gametes to the embryo sac, growing through the tissues of stigma and style. One of the male gametes fuses with the egg cell to form a zygote (syngamy).

The other male gamete fuses with the diploid secondary nucleus to produce the triploid Primary Endosperm Nucleus (PEN). Because of the involvement of above mentioned two events, it is known as double fertilisation. After fertilisation, synergids and antipodal cells degenerate.

The zygote develops into embryo and the primary endosperm nucleus develops into an endosperm.

The ovule gradually transforms into a seed and the ovary becomes the fruit. A fruit is actually a ripened ovary. They not only protect the seed but also help in their dispersal.

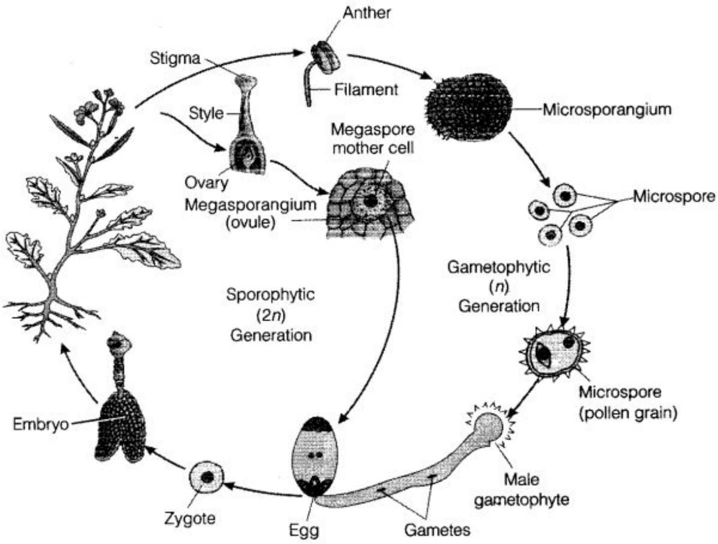


Fig. 3.9 Life cycle of an angiosperm

Differences between Gymnosperm and Angiosperm

Gymnosperms	Angiosperms
Vessels or trachea is absent in xylem.	Trachea is present in xylem.
Phloem contains sieve cells.	Phloem tissue contains sieve tube and companion cells.
Sporophyll are aggregated to form cones.	Sporophyll are aggregated to produce flowers.
Sepals and petals absent.	Sepals and petals present.
Cones are generally unisexual.	Flowers are generally bisexual.
Microsporophyll are broad and leaf like.	Microsporophyll have a stalk and terminal anthers.
Megasporophylls are woody and there is no rolling of megasporophylls.	The magasporophyll are softer and rolled into ovary, style and stigma.
Ovules are exposed.	Ovules are enclosed in ovary.
Archegonia is present	Archegonia absent.
Pollen enters micropyle directly.	Pollen germinates on stigma, pollen tube passes through style to enter ovary.
Single fertilisation.	Double fertilisation
Endosperm is haploid and formed before fertilisation.	Endosperm is triploid and formed after fertilisation.
Seeds exposed because there in no ovary, so no fruit formation.	Seed are enclosed in a fruit which forms after fertilisation.

Classification of Angiosperms

George Bentham and Joseph Dalton Hooker presented the system of classification of angiosperm* published in Genera Plantarum (1862-1883) which appeared in three volumes.
This system of classification is used by most of the well known Herbaria of the world. The details of this system are not described here. Conveniently, on the basis of the number of cotyledons angiosperm are classified in two broad groups i.e., Monocotyledonae and Dicotyledonae.

Differences between Monocots and Dicots

Monocots	Dicots
They contain one cotyledon.	They contain two cotyledons.
Leaves have parallel venation.	Leaves have reticulate venation.
Fibrous root system is present.	Tap root system is present.
Stomata are dumb-bell shaped.	Stomata are kidney- shaped.
Vascular bundles are scattered.	Vascular bundles are arranged in rings.
Cambium is absent.	Cambium is present.
Stems do not have concentric arrangement of tissue. A ground tissue is present.	Stems have concentric arrangement of tissue epidermis cortex, endodermis, pericycle, pith, etc.
Secondary growth is absent with some exception in stems.	These show secondary growth in stem.
Root has pith in its centre.	Root is generally devoid of pith.
Secondary growth is absent in roots with some exception.	Secondary growth occurs in roots.

Economic Importance of Angiosperms
(i) The angiosperms are major source of food, fibers, spices and beverages.
(ii) They also provide valuable timber and medicines.
(iii) These also add beauty to our environment as well.

Alteration of Generation
Life cycle of an organism is a sequence of events that occur from birth to death of an organism. In plants, both haploid and diploid cells can divide by mitosis.
This feature leads to the formation of different plant bodies haploid and diploid. The haploid plant body produces gametes by mitosis. This plant body represents a gametophyte.

After fertilization, zygote also divides by mitosis to produce a diploid saprophytic plant body. Haploid spores are produced by this plant body by meiosis. These in turn, divide by mitosis to form a haploid plant body once again.
Thus, during the life cycle of any sexually reproducing plant, there is an alternation of generation between gamete producing haploid gametophyte and spore producing diploid saprophyte.

Plant Life Cycles
Different plant groups and individual have different features in their life cycle

Haplontic
The dominant photosynthetic phase is a gametophyte produced by haploid spores. The gametophyte produces gametes by mitosis.
The gametes fuse and produce a diploid zygote, that represents sporophytic generation. There are no free living sporophytes. Meiosis in the zygote results in formation of haploid spores. This kind of life cycle is called haplontic.
Many algae such as Volvox, Spirogyra and Chlamydomonas represent this pattern of life cycle.

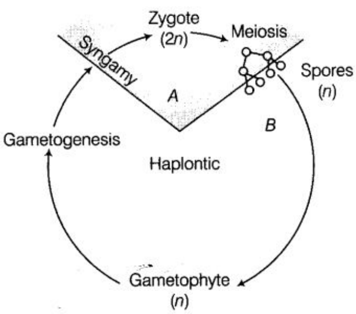


Fig. 3.10 Life cycle pattern : Haplontic

Diplontic
In this type, the diploid sporophyte is the dominant. The multicellular diploid phase is called sporophyte. The gametophytic phase is represented by the single to few celled haploid gametophyte.
This kind of life cycle is termed as diplontic. All seed bearing plants, gymnosperms and angiosperms follow this pattern of life cycle. Fucus, an alga is diplontic.

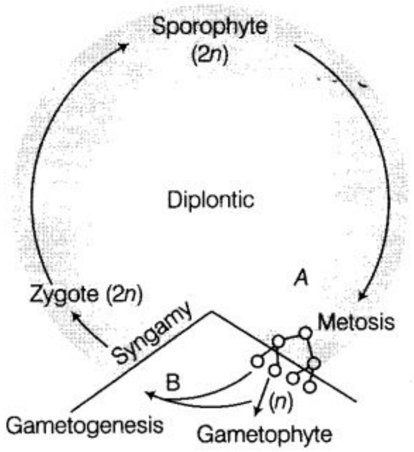


Fig. 3.11 Life cycle pattern: Diplontic

Haplodiplontic

In this type, there are two distinct multicellular phases, diploid sporophyte and haploid gametophyte are present. Both phases are multicellular. However, they dilfer in their dominant phases.

(i) A dominant, independent, photosynthetic, thalloid or erect phase is represented by a haploid gametophyte. It alternates with the short lived multicellular sporophyte totally, partially or dependent on the gametophyte for its anchorage and nutrition. All bryophytes represent this pattern.

(ii) The diploid saprophyte is represented by a dominant independent photosynthetic vascular plant body. It alternates with multicellular saprophytic/autotrophic, independent but short lived haploid gametophyte. This pattern is called haplodiplontic life cycle. All pteridophytes demonstrate this pattern. However, most algal genera are haplontic, some of them such as Ectocarpus, Polysiphonia and kelps are haplodiplontic.

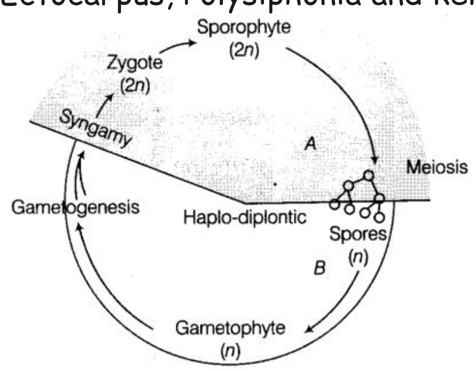


Fig. 3.12 Life cycle pattern: Haplodiplontic

Plant Kingdom Class 5 MCQs Questions with Answers

Question 1.
Rhodophyceae is called red algae because of the pigment
(a) Fucoxanthin
(b) Phycoerythrin
(c) Carotenoids
(d) Chlorophyll c
Answer
Answer: (b) Phycoerythrin
Explanation:
Members of Rhodophyceae are commonly called red algae because of the predominance of the red pigment, r-phycoerythrin in their body.

Question 2.
Which of the followings plant material is an efficient water imbibant?
(a) Agar
(b) Cellulose
(c) Lignin
(d) Pectin
Answer
Answer: (a) Agar

Question 3.
In a monoecious plant
(a) Male and female sex organs are on the same individual
(b) Male and female gametes are of two morphologically distinct types
(c) Male and female sex organs are on different individuals
(d) All the stamens are fused to form one unit
Answer
Answer: (a) Male and female sex organs are on the same individual

Question 4.
The seedless vascular plants whose sporophytes are larger than their small and independent gametophytes are
(a) Pteridophytes
(b) Angiosperms
(c) Gymnosperms
(d) None of these

Answer
Answer: (a) Pteridophytes

Question 5.
Which of the following is a liverwort?
(a) Sphagnum
(b) Funaria
(c) Marchantia
(d) Polytrichum
Answer
Answer: (c) Marchantia
Explanation:
Marchantia is a liverwort.
Sphagnum, Funaria and Polytrichum are mosses.

Question 6.
Transgenic plants are the ones
(a) Grown in artificial medium after hybridization in the field
(b) Produced by a somatic embryo in artificial medium
(c) Generated by introducing foreign DNA in to a cell and regenerating a plant from that cell
(d) Produced after protoplast fusion in artificial medium
Answer
Answer: (c) Generated by introducing foreign DNA in to a cell and regenerating a plant from that cell

Question 7.
Which of the following plants is used extensively for the study of photosynthesis?
(a) Amaranthus
(b) Asparagus
(c) Chlorella
(d) Sunflower
Answer
Answer: (c) Chlorella

Question 8.
Which of the following is used to grow microbes?
(a) Laminaria

(b) Gelidium
(c) Chlorella
(d) Sargassum
Answer
Answer: (b) Gelidium
Explanation:
Agar is extracted from Gelidium and Gracilaria, it is used to grow microbes and in preparation of ice-cream and jellies.

Question 9.
Isogamous condition with non-flagellated gametes is found in
(a) Chlamydomonas
(b) Spirogyra
(c) Volvox
(d) Fucus
Answer
Answer: (b) Spirogyra

Question 10.
Gymnosperms produce neither flower nor fruit because they do not possess
(a) Embryo
(b) Ovary
(c) Ovule
(d) Seed
Answer
Answer: (b) Ovary

Question 11.
Rhodophyceae is called red algae because of the pigment
(a) Fucoxanthin
(b) Phycoerythrin
(c) Carotenoids
(d) Chlorophyll c
Answer
Answer: (b) Phycoerythrin
Explanation:
Members of Rhodophyceae are commonly called red algae because of the predominance of the red pigment, r-phycoerythrin in their body.

Question 12.
In moss stomata appears on
(a) Capsule
(b) Leaves
(c) Stem
(d) All of these
Answer
Answer: (a) Capsule

Question 13.
The gametophyte is not an independent, free-living generation in
(a) Pinus
(b) Polytrichum
(c) Adiantum
(d) Marchantia
Answer
Answer: (a) Pinus

Question 14.
In gymnosperms, the development of pollen grains occurs in
(a) Strobili
(b) Microsporangia
(c) Megasporangia
(d) Macrosporangia
Answer
Answer: (b) Microsporangia
Explanation:
In gymnosperms, the development of pollen grains occur in microsporangia.

Question 15.
Ribbon shaped chloroplasts occur in
(a) Ulothrix
(b) Spirogyra
(c) Chlamydomonas
(d) Riccia
Answer
Answer: (b) Spirogyra

Question 16.
Antheridia and Archegonia are sex organs of
(a) Moss
(b) Mucor
(c) Spirogyra
(d) Puccinia
Answer
Answer: (a) Moss

Question 17.
Iodine is found in
(a) Spirogyra
(b) Laminaria
(c) Polysiphonia
(d) Chlorella
Answer
Answer: (b) Laminaria

Question 18.
Bryophytes are called amphibians of plant kingdom because
(a) These plants live in soil and depend on marine organisms for asexual reproduction.
(b) These plants live in soil and depend on water for sexual reproduction.
(c) These plants live in water and depend on land animals for sexual reproduction.
(d) These plants live near water bodies.
Answer
Answer: (b) These plants live in soil and depend on water for sexual reproduction.
Explanation:
Bryophytes are called amphibians of plant Kingdom because they live in soil and depend on water for sexual reproduction.
They usually occur in damp humid and shaded areas.

Question 19.
Which one of the following is a vascular cryptogram?
(a) Cedrus
(b) Equisetum

(c) Ginkgo
(d) Marchantia
Answer
Answer: (b) Equisetum

Question 20.
Pinus differs from mango in having
(a) Tree habit
(b) Green leaves
(c) Ovules not enclosed in ovary
(d) Wood
Answer
Answer: (c) Ovules not enclosed in ovary

Topics and Subtopics in **NCERT Solutions for Class 11 Biology Chapter 3 Plant Kingdom:**

Section Name	**Topic Name**
3	Plant Kingdom
3.1	Algae
3.2	Bryophytes
3.3	Pteridophytes
3.4	Gymnosperms
3.5	Angiosperms
3.6	Plant Life Cycles and Alternation of Generations
3.7	Summary

NCERT TEXTBOOK QUESTIONS SOLVED

1.What is the basis of classification of algae?
soln. Fritsch (1935), has classified algae considering phylogeny, affinities and inter-relationships of various forms. He classified algae mainly on the basis of the characters like structure of plant body, nature of the pigments, reserve food material, number and position of flagella, chemistry of cell wall and methods of reproduction etc. Algae is divided into 11 classes but among them 3 main classes are Chlorophyceae, Phaeophyceae and Rhodophyceae.

2.When and where does reduction division take place in the life cycle of a liverwort, a moss, a fern, a gymnosperm and an angiosperm?

soln. All of these plants show life cycle with one gametophytic (n) generation and one sporophytic (2n) generation. Reduction division or meiosis that produces haploid (n) cells from diploid cells (2n) is necessary in their life cycles to restore gametophyte generation after sporophytic generation. It occurs in different body structures according to the basic body design of these groups. Reduction division in a liverwort and moss takes place at the end of the sporophytic generation, where haploid spores are formed by reduction division of spore mother cell inside capsule. Spores germinate to produce dominant gametophytic generation. Reduction division in fern takes place at the end of the dominant sporophytic generation inside the sporangium from spore mother cell by reduction division. Spores may be of one type (homospory) or of two types (heterospory).

Reduction division in gymnosperms takes place at the end of dominant sporophytic generation. Megaspore and microspores are produced by the reduction division of diploid megaspore mother cell and diploid microspore mother cell respectively, inside megasporangium and microsporangium. Reduction division in angiosperms takes place at the end of dominant sporophytic generation. The haploid pollen grain or microspore and the haploid egg cell are produced by the reduction division of diploid (microspore) mother cell and diploid megaspore mother cell respectively. Microsporic division occurs inside anther and megasporic division occurs inside gynoecium (ovary).

3.Name three groups of plants that bear archegonia. Briefly describe the life cycle of any one of them.

soln. The three groups of plants that bear archegonia are bryophytes, pteridophytes and gymnosperms.

Life cycle of a bryophyte is as follows : The main plant body of bryophyte is gametophytic (n), which is independent and may be thallose (no differentiation in root, stem, leaves) e.g., Riccia, or may be foliose (having leafy axis) e.g., Funaria. The dominant phase in the life cycle of Funaria is the gametophyte, which occurs in two stages, the protonema stage and the erect, leafy gametophytic plant.

The leafy gametophyte consists of an upright, slender axis (stem-like) that bears spirally arranged leaves and is attached to the substratum by multicellular, branched rhizoids. Vegetative reproduction takes place by fragmentation; by the buds formed in secondary protonema etc. The sex organs, antheridia and archegonia are produced in dusters at the apices of the leafy shoots. Antheridia produces antherozoids and archegonia produces egg.

Antherozoid (male gamete) and egg (female gamete) fuses and form zygote.Zygote develops into a sporophyte; which is differentiated into foot, seta and capsule and spores are produced in the capsule.
Spores on reaching a suitable substratum germinate to produce a filamentous juvenile stage, .called the primary protonema, which later produces secondary protonema that forms erect leafy plants.

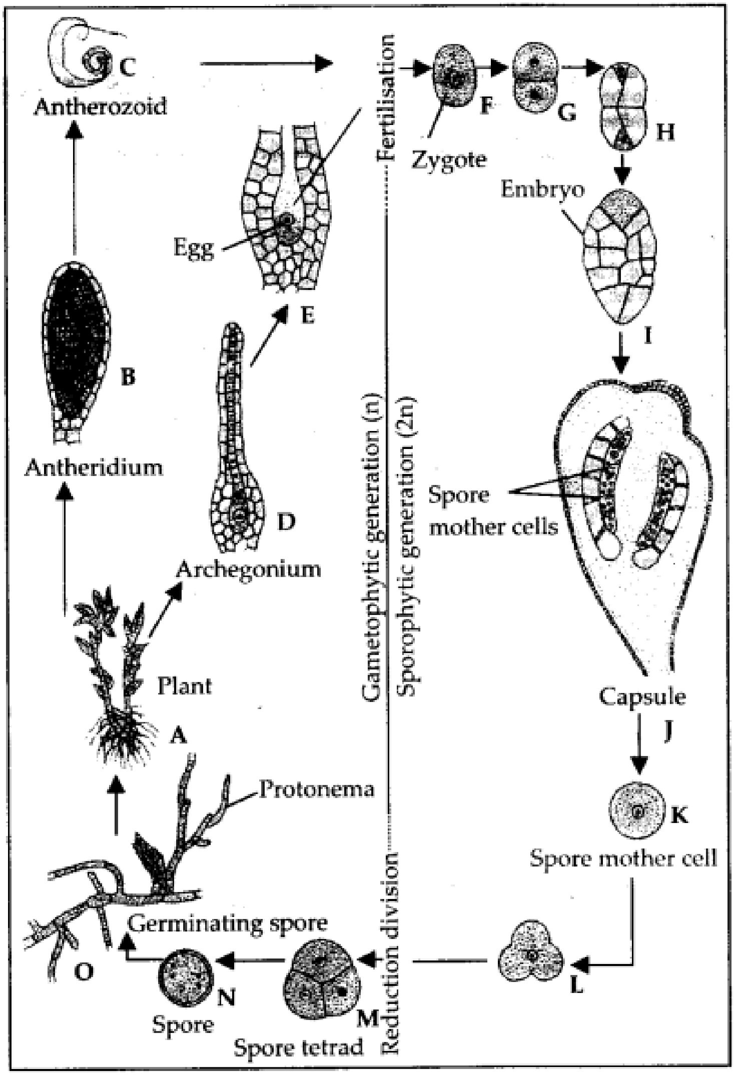


Fig.: Diagrammatic representation of life cycle of *Funaria*

4.Mentiontheploidyofthefollowingrprotonemal cell of a moss; primary endosperm nucleus in dicot, leaf cell of a moss; prothallus cell of a fern; gemma cell in Marchantia; meristem cell of monocot, ovum of a liverwort, and zygote of a fern.

soln. Protonemal cell of a moss – haploid. Primary endosperm nucleus in dicot – triploid.
Leaf cell of a moss – haploid.

Prothallus cell of a fern – haploid.
Gemma cell in Marchantia – haploid. Meristem cell of monocot – diploid.
Ovum of a liverwort – haploid.
Zygote of a fern – diploid.

5.Write a note on economic importance of algae and gymnosperms.

soln. Economic importance of algae is as follows:
The group Algae plays both economically beneficial as well as harmful roles.
Beneficial importance :
(i) People of coastal countries have been using sea weeds & certain other algae as source of food, e.g., Porphyra, Ulva, Laminaria, etc.
(ii)Some algae are used as food for marine as well as domestic animals, e.g., Sargassum, Macrocystis.
(iii)Algae are useful source of many commercial products like agar, a jelly like substance (complex polysaccharide) is extracted form species of red algae belonging to the genera Gelidium, Gracilaria etc. Agar is also used as base in culture media. Carrageenin occurs as a cell wall polysaccharide, esterified with sulphate. It is extracted from red alga like Chondrus Crispin, etc. is used in pharmaceutical emulsifier and textile, leather, cosmetic industries. Alginates are salts of alginic acid found in the cell wall of phaeophyceae (brown algae) like Fucus, Laminaria etc.
(iv)Algae are also useful in medicine industry. Antibiotic chlorellin is obtained from Chlorella. Extracts of Cladophora, Lyngbya kill strains of Pseudomonas and Mycobacterium like bacteria. Nitella is used to destroy mosquitoes growth in ponds and hence used in control of malaria.
(v) Some algae are used in agriculture like Nostoc, Anabaena etc. are used to convert atmospheric N2 into nitrogenous compounds which are absorbed by higher plants. Some sea weeds like Fucus, Litlwphyllum, Lycophyllum etc. are rich io K, P, trace elements and growth substances and are used as fertilisers by coastal people.
(vi)Some algae like Chlorella, Chlamydomonas, etc. are used in sewage disposal in ponds. These algae help in bacterial decomposition by providing 02.
(vii)Some algae like Chlorella, Synecoccus, etc are used in space travels. A person inside a spaceship will need a device to get rid of C02 and other body wastes and will require sources of Oz and food. These algae are very useful for this purpose.
(viii)A large amount of iodine (mineral element present in thyroxine hormone of thyroid gland) is extracted from kelps (brown sea weeds or members of phaeophyceae) like Laminaria, Fucus, Ascophyllum etc. Similarly red algae like

Rhodomela, Polysiphonia, Rhodymenia are sources of bromine.
Harmful importance:
(i) Some blue green and green algae like Chroococcus, Oscillatoria grow over the surface of water bodies in abundance and cause water bloom. On death and decay these algae give off bad smell. Some algae secrete poisonous or toxic substances.
(ii)Parasitic algae like Cephaleuros virescens causes red rust of tea, coffee etc.
Economic importance of gymnosperms is as follows:
(i)Some species of Cycas like C. revoluta, C. rumphii look like palm tree and are used for decoration purposes as they remain fresh for long period.
(ii)Stem portion of Cycas revoluta is a good source of 'sago', a kind of starch used in making bread by poor people. Seeds of some species of Cycas are roasted and taken as food. Young succulent leaves of some species of Cycas are cooked as vegetable.
(iii)Many gymnospersm have medicinal value. The fresh juice extracted from the Cycas circinalis leaves is used as medicine for stomach disorders, blood vomiting and other skin diseases. Pollen grains of some Cycas plants are reported to have some narcotic effect.
(iv)Some gymnosperms like Pinus, Abies, Cedrus are the chief source of various types of woods. The wood of Juniperus is used in making pencils, scales, holders etc.
(v)Some species of Pinus is a good source of turpentine, wood gas, wood alcohol.

6.Both gymnosperms and angiosperms bear seeds, then why are they classified separately?

soln.'Gymnosperms and angiosperms both bear seeds but they are classified separately because gymnosperms are a group of plants in which the ovules are freely exposed on open megasporophylls, whereas in angiosperms the seeds or ovules are enclosed within ovary which later forms the fruit.

7.What is heterospory? Briefly comment on its significance. Give two examples.

soln. The occurrence of two kinds of spores in the same plant is called as heterospory. Among them the smaller spore is called microspore and the larger spore is called megaspore. Heterospory first evolved in pteridophytes. Significance of heterospory
(i) Heterospory is associated with the sexual differentiation of gametophyte /.<?., a microspore develops into a male gametophyte whereas a megaspore develops into a female gametophyte.

(ii)In homosporous pteridophytes spores have to germinate on soil thus face more environmental problems. In heterosporous pteridophytes, spores germinate within the sporangium and the gametophytes are retained inside for variable periods of time. Hence, germinating gametophyte has better chances of survival. This lays the foundation of complete retention of gametophytes within sporophytes in angiosperms and gymnosperms.
(iii)Heterospory is the basis of development of seed habit in higher plants.

8.Explain briefly thefollowing terms with suitable examples.
(i) Protonema (ii) Antheridium
(iii)Archegonium (iv) Diplontic (v) Sporophyll (vi) Isogamy

soln. (i) Protonema : It is the first, usually branched, green and filamentous structure produced by a germinating moss or fern spore. The protonema of mosses bears buds that develop into the gametophyte plant. In fern the protonema becomes the prothallus.
(ii)Antheridium : The male sex organ of cryptogams (algae, fungi, bryophytes and pteridophytes) is known as antheridium. It produces the male gametes or anthero-zoids. It may consist of a single cell or it may have a wall that is made up of one or several layers forming a sterile jacket around the developing gametes.
(iii)Archegonium : The multicellular flask shaped female sex organ of bryophytes, pteridophytes and many gymnosperms is known as archegonium. Its dialated base called the venter contains the female gamete or egg or oosphere. The cells of the narrow neck of archegonium liquify to allow the male gametes to swim towards the oosphere.
(iv)Diplontic : It is the kind of life cycle in which the diploid sporophyte is dominant and this diploid phase is photosynthetic. The gametophytic phase is represented either by gametes only, that are formed through meiosis or by a highly reduced few celled gametophyte. E.g., all seed-bearing plants (gymnosperms and angiosperms).
(v) Sporophyll : It is a type of leaf bearing sporangia. In ferns, the sporophylls are the normal foliage leaves, but in other plants the sporophylls are modified and arise in specialised structure such as the strobili of club-moss, gymnosperms and the flower of angiosperms. In most plants sporophylls are of two types – microsporophylls and megasporophylls.
(vi)Isogamy: It is a type of sexual reproduction where fusion takes place between two identical gametes. The gametes are similar in size and structure and they show equal motility during sexual reproduction, e.g., Spirogyra (algae).

9.Differentiate between the following:
(i) Red algae and brown algae
(ii)Homosporous and heterosporous pteridophytes
(iii)Liverworts and moss
(iv)Syngamy and triple fusion.

soln.(i) The differences between red algae and brown algae are as follows :

	Red algae	Brown algae
(i)	The major pigment of red algae are chlorophyll *a,d* and phycoerythrin.	The major pigment of brown algae are chlorophyll *a, c,* and fucoxanthin.
(ii)	In red algae, floridean starch is the stored food material.	In brown algae, mannitol and laminarin are the stored food materials.
(iii)	In red algae cellulose is present in cell wall.	In brown algae cellulose and algin are present in cell wall.
(iv)	Flagella are absent.	The number of flagella is 2, they are unequal in size and lateral in position.
(v)	Thylakoids are unstaked.	Thylakoids occur in groups of three.

(ii) The differences between homosporous and heterosporous pteridophytes are as follows:

	Homosporous pteridophytes	Heterosporous pteridophytes
(i)	In these pteridophytes only one kind of spore is produced.	In these pteridophytes two kinds of spores are produced.
(ii)	The spores are equal in size.	The smaller spores are called microspores and the larger spores are called megaspores.
(iii)	The spores are produced from the same sporangia.	The microspores are produced from the microsporangia and the megaspores are produced from the megasporangia.
(iv)	The spores develop one kind of gametophyte.	The microspore develops into male gametophyte whereas the megaspore develops into female gametophyte.
(v)	Spores germinate in soil and produce independent gametophyte.	Spores germinate within sporangia and produce dependent gametophyte.
(vi)	*e.g., Lycopodium*	*e.g., Selaginella, Salvinia.*

(iii) The differences between liverworts and mosses are as follows :

	Liverworts	Mosses
(i)	The gametophytic plant body may be thallose (*e.g., Riccia*) or foliose.	Gametophytic plant body is differentiated into prostrate, branched filamentous, thalloid protonema and leafy erect gametophore.
(ii)	On the ventral surface of the thallus unicellular rhizoids and simple multicellular scales are present.	The rhizoids are multicellular, branched with oblique septa.
(iii)	Sex organs are present on dorsal surface of the thallus and develop from superficial cells.	The sex organs develop from the superficial cells at the apex of leafy gametophyte.
(iv)	Elaters are generally present but absent in *Riccia*.	Elaters are absent.
(v)	Stomata are absent in the wall of the capsule.	Stomata are present in sporophyte for gaseous exchange.
(vi)	Dehiscence of capsule is irregular.	Dehiscence is regular.

(iv) The differences between syngamy and triple fusion are as follows :

	Syngamy	Triple fusion
(i)	It is the generative fertilisation.	It is vegetative fertilisation.
(ii)	Both male and female gametes are involved in syngamy.	Only one male gamete and two vegetative nuclei are involved in triple fusion.
(iii)	Syngamy produces a diploid zygote.	It produces a triploid primary endosperm cell.
(iv)	Zygote forms the embryo.	Primary endosperm cell produces a food laden endosperm.

10. How would you distinguish monocots from dicots?

Soln. Differences between monocots and dicots are as follows :

	Monocots	Dicots
(i)	The seeds contain one cotyledon.	The seeds contain two cotyledons.
(ii)	Flowers are generally trimerous.	Flowers are generally pentamerous or tetramerous.
(iii)	Pollen grains generally possess a single germ pore.	Pollen grains commonly have three germ pores.
(iv)	Leaves generally possess parallel venation.	Leaves posses reticulate venation.
(v)	Primary root is short lived. Tap root is absent. Adventitious roots present.	Primary root is long lived and it forms tap root. Adventitious roots are found in some cases.
(vi)	In stems, ground tissue is not differentiated into cortex and pith.	In stems, ground tissue is differentiated into cortex, pith, endodermis etc.
(vii)	Vascular bundles are scattered and closed. Cambium absent.	Vascular bundles are arranged in a ring and open. Cambium present.
(viii)	In root, a pith is always present. Vascular bundles are many (more than 8).	In root, pith is absent. Vascular bundles are few.
(ix)	Vessels are rounded in outline.	Vessels are polygonal in outline.

11.Match the following (Column I with Column II).

Column I	Column II
(a)Chlamydomonas	(i)Moss
(b)Cycas	(ii)Pteridophyte
(c) Selagmella	(iii)Algae
(d) Sphagnum	(iv)Gymnosperm

Soln.

Chlamydomonas – Algae
Cycas – Gymnosperm
Selayinella – Pteridophyte
Sphagnum – Moss

12.Describe the important characteristics of gymnosperms.

Soln. The term gymnosperm is derived from two Greek words: Gymnos = naked + Sperma = seed, i.e., naked seeded plants. So gymnosperms are a group of plants inwhich the ovules are freely exposed on open megasporophylls. The important characteristics of gymnosperms are :

– Living gymnosperms are perennial and vary from predominantly medium – sized trees (Cycas) to tall trees (Pinus) and shrubs (Ephedra).
– Plants possess tap root system. Some genera possess symbiotic relationship of N2 fixing algae in coralloid roots (Cycas) and fungi in mycorrhizal roots (Pinus).
– The stems are aerial, erect, branched (unbranched in Cycas) and woody.
– The leaves may be simple or compound. They are scaly and foliage also. Leaves are well adapted to withstand extremes of temperature, humidity and wind.
-Roots are characterised by the presence of diarch to polyarch vascular bundles. Xylem is exarch.
-Stems are provided with collateral, endarch and open vascular bundles which are arranged in a ring. Secondary growth is present and annual rings are formed.
-Xylem contains xylem parenchyma and tracheids with bordered pits and vessels are absent (except in Gnetum; Ephedra and Wehmtschia).
-Phloem contains sieve cells and phloem parenchyma and companion cells are absent (except in Gnetum; Ephedra and Weluhtschia).
-Leaves are protected by thick layers of cuticle. Sunken stomata are present. Mesarch xylem and transfusion tissues are found in the leaves. Palisade tissue and spongy parenchyma may be present in mesophyll or it may be undifferentiated.
-The reproductive organs form cones or strobilus except female organs of Cycas.
-The male cone is made of overlapping microsprophylls, that bear micros¬porangia on the abaxial side which produce microspores.
-Female cone is formed by overlapping megasporophylls which bear ovules

(megasporangia).

-Ovule is orthotropous, unitegmic with 3 layers i.e. outer fleshy, middle stony and inner fleshy.

– The nucellus of ovule contains single megaspore mother cell which undergoes reduction division to form 4 megaspores, out of which 3 degenerate and only one survives.

– So gymnosperm is heterosporous i.e. producing microspores and megaspores.

– Single megaspore forms haploid female gametophyte or endosperm before fertilisation. .

– At micropylar end of female gametophyte 2 or more archegonia are produced. Archegonium is with reduced neck (with no neck canal cell).

– Microspores are released from microsporangium and are carried in air currents and come in contact with the micropyle of the ovules.

– Pollen tube carrying the male gametes grows towards archegonia and discharges its contents near the mouth of the archegonia.

– After fertilisation zygote or oospore gives rise to embryo proper and the ovules develop into seeds.

– Polyembryony i.e., development of more than one embryo is an usual feature of gymnosperms but only one of them survives at later stage.

– In embryo 2 or many cotyledons are present.

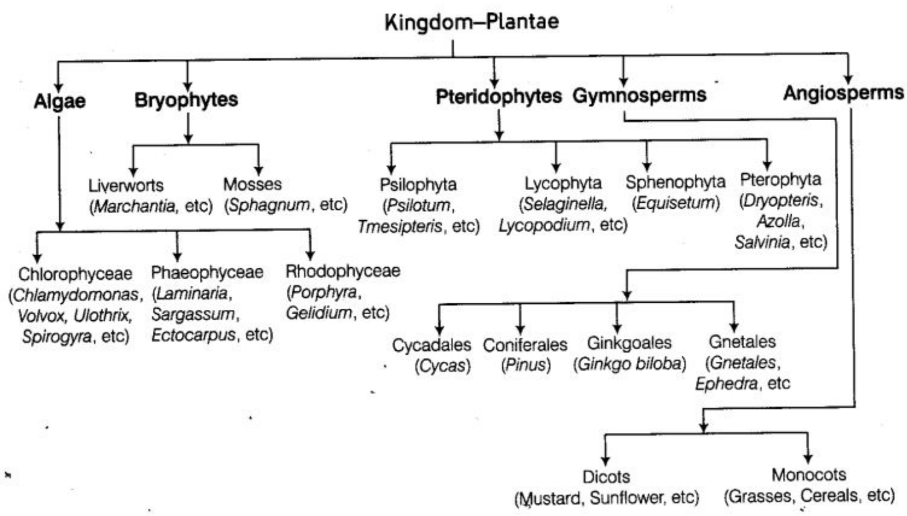
– The seeds of gymnosperms are uncovered.

Plant Kingdom Class 5 Notes Biology Chapter 3

- Basis of Classification and Algae, Bryophytes & Pteridophytes
- Types of Taxonomies
- Classification of Algae
- Bryophytes
- Pteridophytes
- Gymnosperms, Angiosperms and Plant Life Cycles
- Classification of Angiosperms

Basis of Classification and Algae, Bryophytes & Pteridophytes

Our understanding of the plant kingdom has changed over time. Fungi and members of the Monera and Protista having cell walls have not been separated form Plantae, the earlier classifications kept them in the same kingdom. The kingdom-Plantae has been described under algae, bryophytes, pteridophytes, gymnosperms and angiosperms. The overview of this classification is demonstrated here in the flowchart.



Types of Classification System

These includes artificial system, natural system and phylogenetic system of classification.

The various systems used in classification ofiplants are being discussed here

1. Artificial System of Classification

This system is based on comparison of one or a few superficial characteristics, which are helpful in easy identification of organisms. This system remained in use for about two thousand years.

Aristotle is known as father of Zoology.

Carolus Linnaeus is known as father of Taxonomy.

Advantages

Advantages of artificial system as below

(i) Artificial system is easy to remember as only one or few characters are used.

(ii) The traits used are of interest to humans.

Disadvantages

Disadvantages of artificial system are given below

(i) This system use only few superficial characters (i.e., habits, numbers, colours and shapes of leaves, etc) which leads to many organisms grouped together,

(ii) They considered mainly the vegetative characters or the androecium characters as given by linnaeus.

(iii) It does not demonstrate natural and phylogenetic relationships.

(iv) This gave equal weightage to vegetative and reproductive/sexual characters this is not acceptable, as vegetative characters are more easily influenced by the environmental factors.

(v) They sparated the closely related species.

2. Natural System of Classification

It is also known as phenetic system of classification. The natural system of classification is based on natural affinities among the organisms. It considers both external and internal features like structure, anatomy, embryology and phytochemistry.

Advantages

Advantages of natural system are given below

(i) Only related organisms are kept in a group.

(ii) Unrelated organisms are kept in separate groups.

(iii) It shows natural relationships among the organisms.

(iv) It shows possible origin of different taxa.

Disadvantages

Disadvantages of natural system are given below

(i) There is more emphasis given on natural character.
(ii) In this system several related families are separated and unrelated families are put together.
(iii) Evolutionary basis is neglected.

3. Phylogenetic System of Classification

The phylogenetic system of classification indicates the evolutionary as well as genetic relationships among organisms. This system is based on fossil records of biochemical, anatomical, morphological, physiological, embryological and genetical. The system was initiated by Engler and PrantI (1887-1899) in Die Naturalichen Pflanzefamilien. In phylogenetic system, flowering plants are placed in ascending series related to complexity of floral morphology. The phylogenetic system of classification are mainly the rearrangement of taxonomic characters in addition to the phylogenetic information.

Advantages

Advantages of phylogenetic system are given below

(i) Families and order in this system are of small size.
(ii) This system is in conformation with the modern views of phylogeny.
(iii) They use information from various sources to solve problems of classification. Such informations become more important in the absence of supporting fossil evidences.

Disadvantages

Disadvantages of phylogenetic system are given below

(i) This is not helpful in plant identification.
(ii) The classification is outdated as the habit is used as . main basis of classification.

Types of Taxonomies

For the suitability in studies various categorizations has been done in taxonomy.

The important taxonomies are as follows

1. Numerical Taxonomy

It is carried out by quantitative assessment of similarities and differences in order to make objective assessments. It is now easily carried out using computers based on all observable characteristics. Number and codes are assigned to all the characters and the data are then processed. In this way, each character is given equal importance and at the same time hundreds of characters can be considered.

2. Cytotaxonomy

Cytotaxonomy is based on cytological information like chromosome number, structure, behaviour and type of chromosomes. For example,

(i) Chromosome number is constant for a species, e.g., 46 in man, 48 in apes and potato, 20 in maize, 16 in onion and 8 in Drosophila.

(ii) Behavior of chromosomes was used by taxonomists during pairing and banding patterns to understand the relationships between species, e.g, Origin of humans from apes, origin of wheat, etc.

3. Chemotaxonomy

It is the system based on the evidences from chemical constituents (enzymes, hormones, proteins, amino acids, etc.), some specific chemicals (usually secondary metabolites) and the chemical nature of proteins have been utilised to establish similarities and relationships. For example, the presence of raphides has been found to be common in 35 families of plants.

Algae

Algae are chlorophyll-bearing, simple, thalloid, autotrophic and largely aquatic (both freshwater and marine) organisms.

The important salient features of algae are given below

Habitat

These are found in both freshwater and marine habitats. Some algal forms are also found in moist habitats like wet rocks and soil, tree trunks, etc. Some of them are also found in close association with fungi (lichen) and animals {e.g., on sloth bear).

Thallus Organisation

The plant body (thallus) is without differentiation. The basic form and size of algae is highly variable, and ranges from filamentous {e.g., Ulothrixand Spirogyrd) to colonial {e.g., Volvox). These are attached on the substratum with the help of holdfast.

Structure of Algal Cell

It has an eukaryotic plant cell structure. The cytoplasm contains membrane bound chloroplast, mitochondria, ER, Golgi bodies and other cell organelles. The cell wall contains cellulose. The nucleus contains nuclear membrane.

Food Material

Algae have main food reserve as starch. In brown algae, mannitol and laminarin are the main reserve food material, whereas in red algae floridean starch is the reserve food material.

Reproduction

The algae reproduces vegetatively, asexually and sexually.

i. Vegetative Reproduction

It occurs by fragmentation, tubers, stolons, adventitious branches, etc. Each fragment gets develop into a thallus.

ii. Asexual Reproduction

It occurs by a number of accessory spores, such as zoospores aplanospores, akinetes, carpospores, etc.

The most common being the zoospores, which are flagellated. The cells which produce spores are called sporangia. The sporangia may be the vegetative cells (e.g. in Chlamydomonas and Ulothrix) or modified vegetative cells (e.g. in Vaucheria).

iii. Sexual Reproduction

It occurs by fusion of two gametes.

On the basis of morphology of reproductive cells, sexual reproduction is of two types

(a) Isogamy In this method, two morphologically similar gametes fuse to form a zygote, e.g., Spirogyra.

(b) Heterogamy In this process, fusion occurs between morphologically as well as physiologically different gametes. It is of two types

Anisogamy It is the fusion of structurally dissimilar gametes, which differ in size and – behaviour. Male gamete is more active and female gamete is less active and bigger in size, e.g., Some species of Chlamydomonas.

* Oogamy In this process, the male gamete is motile, active, small and without reserve food.

The female gamete is bigger, passive, non-motile and laden with food, e.g., Volvox, Fucus.

Embryo and Life Cycle

An embryo stage is not present. Life cycle is haplontic, diplontic, diplohaplontic, haplohaplontic, etc. An alternation of generation occurs in diplohaplontic life cycle.
Economic Importance of Algae
(i) Algae are responsible for carrying out about a half of the total carbon dioxide fixation on earth by the process of photosynthesis.
(ii) Some forms of marine brown and red algae produce large amount of hydrocolloids. These are algin (brown algae) and carrageenan (red algae) which have many commercial uses.
(Hi) The algae Gelidium and Gracilaria are used to produce agar, which is used in preparation of ice creams and jellies.
(iv) Some protein rich algae, like Chlorella and Spirullina are used as food supplements by sailors and space travellers.
(v) About 70 species of marine alga are used as food, e.g., Porphyra, Laminaria and Sargassum.

Classification of Algae

Algae are divided into various classes based on pigmentation, stored food and flagellation. The three main classes are
Chlorophyceae, Phaeophyceae and Rhodophyceae.
i.Class-Chlorophyceae (Green Algae)
The members of Chlorophyceae are commonly called green algae.
There are about 7000 species in this class. The reserve food material is starch.

The characteristic features of Chlorophyceae are discussed below
(a) Habitat These are mostly marine forms, only some are freshwater. Chlorella can tolerate moderately warm waters. Snow dweling forms are called cryophytes, e.g., Chlamydomonas nivalis, Scotiella, etc.
(b) Cell Organisation .These are unicellular, colonial, coenocytic and multicellular forms. Cell walls contain cellulose (inner layer) and pectose (outer layer) in most of the green algae. The chloroplasts may be discoid, plate-like, reticulate, cup-shaped, spiral or ribbon shaped.
The chloroplasts contain pigments. Most of the members have one or more storage bodies called pyrenoids located in" the chloroplasts. Pyrenoids contain protein besides starch. Some algae may store food in the form of oil droplets also.

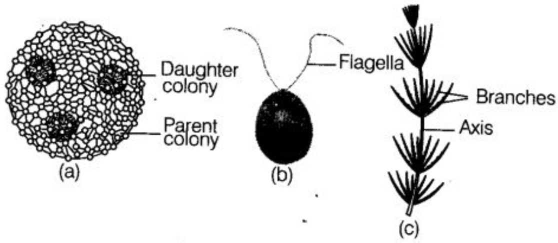


Fig 3.2 Green algae (a) *Volvox* (b) *Chlamydomonas* (c) *Chara*

(c) Thallus Unicellular green algae can- be flagellate, (Chlamydomonas), unicellular, non-flagellate (Chlorella).
Acetabularia (umbrella plant) has unicell upto 10 cm long with distinction of nucleus containing rhizoid, elongated stalk and umbrella like cap.
A colony for fixed number of individual unicells (Volvox) is called coenobium.
Coenocytic or siphonaceaus thallus occurs in Caulerpa. Unbranched filamentous thallus in Ulothrix and Spirogyra, Cladophora, heterotrichous in Stigeoclonium and parenchymatous in Ulva.

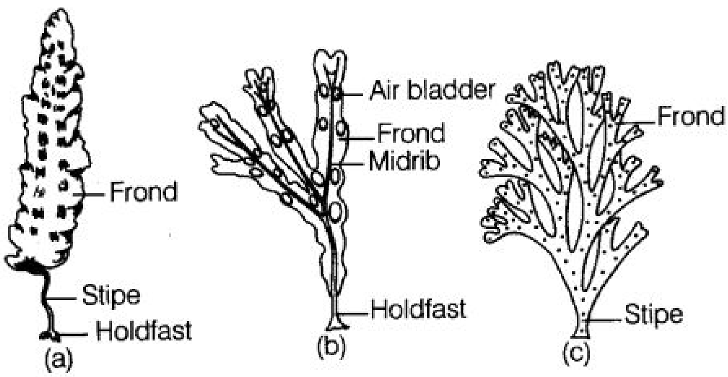


Fig 3.3 Brown algae (a) *Laminaria* (b) *Fucus* (c) *Dictyota*

(d) Reproduction The members of Chlorophyceae reproduce vegetatively, asexually and sexually by various methods.
* Vegetative reproduction occurs through cell division (unicellular forms), fragmentation, stolons, tubers, storage cells, etc.
* Asexual reproduction occurs by zoospores, aplanospores, hypnospores, akinetes and daughters colonies.
* Sexual reproduction may be isogamous, anisogamous or oogamous.

(e) Life Cycle It can be haplontic, diplontic and diplohaplontic. In haplontic life cycle, there is a single somatic phase, which is haploid. Diploid stage is represented by a single cell or zygote, e.g., In Spirogyra.

ii. Class-Phaeophyceae (Brovin Algae)

The members of Phaeophyceae are fucoxanthin and phycocolloid rich multicellular

eukaryotic algae. Its common members are seaweeds called kelps. This class is comprised of about 2000 species.
(a) Habitat Brown algae are mostly marine. These are found mostly in colder seas or during cold seasons in tropical regions.
(b) Size They range from simple branched, filamentous forms (Ectocarpus) to profusely branched forms as represented by kelps. These represent largest algae. The largest kelps are Macrocystis (40-100m) and Nereocystis (20-30 m).

(c) Cell Organisation All members are multicellular. Cell wall is composed of cellulose, pectose and phycocolloids. The cellulosic wall of vegetative cells is usually covered on the outside by a gelatinous coating of algin.

(d) Thallus It is heterotrichous filament with both prostrate and upright branches (Ectocarpus). The parenchymatous structure is found in higher forms. The plant body of large forms often differentiated into holdfast (with which it usually attaches to the substratum) a stalk called the stipe and lamina (frond), which is photosynthetic. Conducting tubes or trumpet hyphae are present in larger brown algae or kelps. They help in conduction of food materials.

(e) Photosynthetic Pigments and Colour These include chlorophyll-4, c and carotenoids. They ranges in colour from olive green to various shades of brown depending upon the amount of the xanthophyll pigment, fucoxanthin present in them.

(f) Food Reserve It remains in the form of complex carbohydrates such as laminarin or mannitol.
(g) Flagellation These contain heterokont flagellation with one smooth (whiplash) and one tinsel flagella.
(h) Reproduction Vegetative reproduction occurs through fragmentation (e.g., Sargassum), adventitious branches and stolons (e.g, Dictyota). Asexual reproduction by biflagellate zoospores, which are pear-shaped having two unequal laterally attached flagella.

Sexual reproduction is performed by isogamy, anisogamy and oogamy. Union of gametes may take place in water or within the oogonium (oogamons species). The gametes are pyriform (pear-shaped) and have two laterally attached flagella.
(i) Life Cycle Isomorphic alternation of generation is found in some brown algae,

e.g, Ectocarpus, Dictyota. In many brown algae, the diploid generation or phase is dominant. The haploid phase is either microscopic or represented by gametes only (e.g., Fucus).

Economic Importance of Pheophyceae

* The brown algae that are used as food are Laminaria, Nerocystis, Macrocystis, Alaria, etc.
* Some brown algae like Fucus, Sargassam, Laminaria, Macrocystis are important fodder for catde.
* Brown algae are collected from sea shores and used as manure. They improve mineral content of soils.
* Alginic acid is a phycocolloid obtained from a number of brown algae such as Alaria, Macrocystis, Ascophyllum, Laminaria. It is used as emulsifier, thickener, gelating agent in toothpastes, shaving creams, ice-creams, emulsion paints, shampoo, cosmetics, etc.
* Fucus and Laminaria are rich in iodine.

iii. Class-Rhodophyceae (Red Alqae)

The members of Rhodophyceae are commonly called red algae because of the predominance of the red pigment,i.e., r-phycoerythrin in their body.
(a) Habitat Most of the red algae are marine with greater concentrations found in the warmer areas. They are found in both well lighted regions close to the surface of water and also at great depths in oceans where relatively little light penetrates.

(b) Thallus The red thalli of most of the algae are multicellular. Some of them have complex body organisation like Asterocystis is pseudofilamentous, Porphyridium is unicellular, Porphyra has parenchymatous sheets, Cbondrus is ribbon like, Gelidium is a multicellular sea weed.

(c) Cell Wall The cell wall contains cellulose, pectic compounds and certain mucopolysaccharides called phycocolloids, such as agar, carrageenin, etc. In many algae, cell wall contains pits.

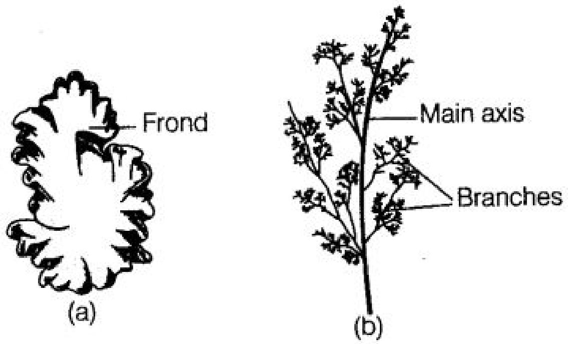


Fig 3.4 Red algae (a) *Porphyra* (*b*) *Polysiphonia*

(d) Photosynthetic Pigments These include chloro¬phyll-4, carotenes, xanthophylls and phycobilins. Phycobilins are water soluble and are of two types, i.e., red-coloured phycoerythrin and blue-coloured phycocyanin.

(e) Reserve Food It is floridean starch similar in constitution to glycogen and amylopectin. if) Reproduction Vegetative reproduction occurs by fragmentation, regeneration of hold fast and gemmae. Asexual reproduction occurs by non-motile spores (carpospores, monospores, tetraspores and neutral spores).

(f) Sexual reproduction occurs by non-motile gametes and is oogamous type. The male sex organs is called spermatogonium or antheridium. The male produced is non-flagellated, called as spermatium. The female sex organ is called carpogonium. After fertilisation, a new structure called carposporophyte is produced. It remains attached to the parent alga.

(g) Life Cycle Life cycle has two or more phases such as haplohaplontic, haplohaplohaplontic, diplodiplohaplontic, etc.

Economic Importance of Red Algae
* The red algae like Porphyra, Chondrus, Rhodymenia, Centerella and Bostrychia are used as food in various parts of the world.
* Agar yielding algae are called aerophytes, such as Gelidium, Gracilaria, Ceramium, Gelidiella, etc.
* Alga like Rhodymenia are used as fodder for cattle.
* Carrageenin a phycocolloid obtained from red algae like Chondrus and Gigartina is used in preparations of emulsions for ice cream, chocolates, sauces, toothpastes, cosmetics, etc. It is also used in clearing liqueurs and finishing leather, etc.
* Funori an adhesive phycocolloid is obtained from red alga Gloiopeltis. It is used in

sizing textiles, paper and as glue.
* Some algae like Corallina, Polysiphonia have medicinal properties.

Bryophytes

Bryophytes include the various mosses and liverworts. These are non-vascular embryophytes, characterised by the presence of. an independent gametophyte and parasitic sporophyte.

Habitat
Bryophytes commonly grow in -moist, shaded areas in hills. These are also called amphibians of the plant kingdom because, these can live in soil but are * dependent on water for sexual reproduction.

Rhizoids
These are attached to the substratum by unicellular or multicellular rhizoids.

Sex Organs
The main plant body produces gametes, hence it is called gametophyte. The sex organs in bryophytes are multicellular, the male sex organs in bryophytes is called antheridium (which produces biflagellate antherozoids) and the flask-shaped female sex organ is called archegonium (produces a single egg).

Reproduction
It is of sexual type reproduction. The antherozoids are released into water where they come in contact with archegonium.

Fertilisation
It occurs inside the archegonium. The egg secretes a chemical which attracts spermatozoids. Sperms require a thin film of water for swimming and reaching the dehisced archegonium. One sperm fuses with an egg and produces a diploid zygote. Zygotes do not undergo reduction division immediately instead, they produce a multicellular body called sporophyte.

Dependent Sporopbvrc The sporophyte is not free-living but attached to the photosynthetic gametophyte deriving nourishment from it. Some cells of the sporophyte undergo reduction division (meiosis) to produce haploid spores (which

germinate to produce gametophyte).
The sporophyte of bryophytes is called sporogonium because it is mainly dependent and meant for producing spores.

Life Cycle
Bryophytes have heteromorphic or heterologous alternation of generation. The gametophyte may be produced directly or first from a juvenile stage called protonema.

Economic Importance
Bryophytes in general are of little economic importance. But, several species have some uses.
(i) Some mosses provide food for herbaceous mammals, birds and other animals.
(ii) Species of Sphagnum (a moss), provides peat that
have long been used as fuel. It has the capacity to hold water as packing material for transshipment of living material.
(iii) Mosses along with lichens are the first organisms to colonise rocks. Hence, these help in biological succession. They decompose rocks making the substrate suitable for the growth of higher plants.
(iv) Mosses from dense mats on the soil, they reduce the impact of falling rain and prevent soil erosion.
(v) Marchantia has medicinal properties to cure lungs and liver infections. It also has antitumour properties.
Bryophytes do not attain great heights. They may range of 0.4 to 70 cm and have thalloid body.

The reasons may be following
(i) Root is absent.
(ii) Vascular tissues are not present.
(iii) Cuticle is not present on the plant body.
(iv) Absence of mechanical tissue.
(v) Male gametes need to swim upto the interior of dehisced archegonia.

Types of Bryophytes
The bryophytes are generally classified into two main groups
i. Liverworts
Liverworts (Hepaticopsida) usually grow in moist, shady places such as banks of streams, marshy ground, damp soil, bark of trees and deep in the woods.

(a) Thallus The plant body of a liverwort is thalloid, e.g, Marchantia,. The thallus is dorsoventral and closely appressed to the substrate. The leafy members have tiny leaf like appendages in two rows on the stem like structure.

(b) Rhizoids These are unicellular. These may be of two types in some liverworts, i.e. smooth walled and tuberculate.

(c) Reproduction It may occur both by asexual and sexual means.
• Asexual Reproduction It occurs by fragmentation of thalli or by the formation of specialised structures called gemmae (sing, gemma). Gemmae are green, multicellular, asexual buds which develop in small receptacles called gemma cups located on the thalli. The gemmae become detached from the parent body and germinate, forming new individuals.

• Sexual Reproduction During this male and female sex organs are produced either on the same or on different thalli. The sporophyte is differentiated into a foot, seta and capsule. After meiosis, spores are produced within the capsule.

• These spores germinate to form free-living gametophytes, e.g., Riccia, Marchantia, Pellia, Porella, etc.

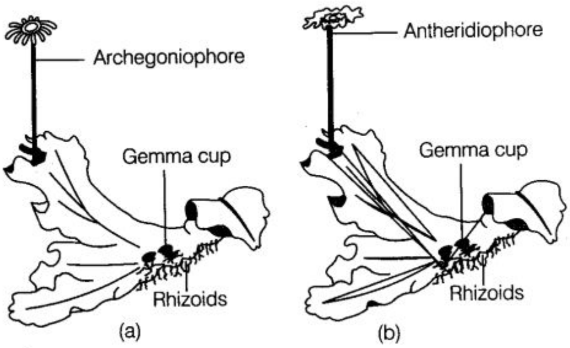


Fig 3.5 A liverwort (*Marchantia*) (a) Female thallus (b) Male thallus

ii. Mosses

Mosses (Bryopsida) grow in dense mats over moist shady places, especially during rains. Some mosses grow in desert bogs and streams.
(a) Plant Body The predominant stage of the life cycle of a moss is the gametophyte which consists of two stages the first stage is the protonema stage which develops directly from a spore. It is a creeping, green, branched and frequently filamentous stage; the second stage is the leafy stage which develops

from the secondary protonema as a lateral bud. They consist of upright, slender axes bearing spirally arranged leaves. This stage bears sex cells.

(b) Rhizoids These are long, multicellular branched structures with oblique septa. They take part in fixation and absorption of water. However, surface conduction through capillarity is an important mechanism of water supply to aerial parts.

(c) Reproduction This can occur both by vegetative and sexual means.
* Vegetative Reproduction It occurs by fragmentation and by budding in the secondary protonema from exposed rhizoids and other parts (like gemmae, buds and tubers).

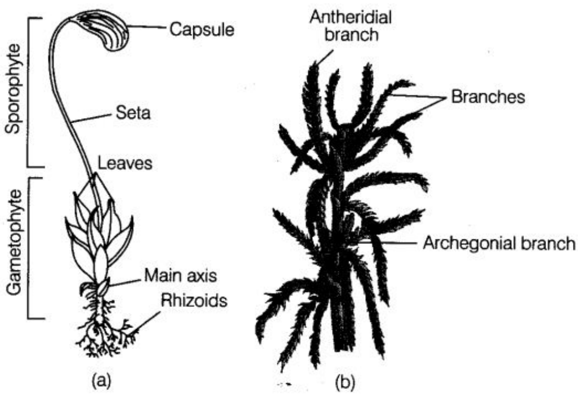


Fig 3.6 Mosses (a) *Funaria*, gametophyte and sporophyte (b) *Sphagnum* gametophyte

Sexual Reproduction Sex organs, antheridia and archegonia are produced at the apex of the leafy surface. Male organs appear cup-shaped, while female organs are bud-like. After fertilisation, the zygote develops into a sporophyte, consisting of foot, seta and capsule (containing spores).

(d) Sporophyte The sporophyte in mosses is more elaborate than that in liverworts. Spores are formed after meiosis. The mosses have an elaborate mechanism of spore dispersal, e.g., Funaria, Polytrichum and Sphagnum.

Differences between Liverworts and Mosses

Liverworts	Mosses
They are dorsiventral.	They have radial symmetry.
Plants are thalloid or foliose.	Mosses are foliose.
Midribs is not present in leaves.	Leaves have unbranched midrib.
Rhizoids are unicellular and unbranched.	Rhizoids are multicellular and branched.
Plants bear scales.	Scales are absent in plants.
A conducting strand is absent.	A conducting strand is commonly present.
Sporophyte is differentiated in foot, seta and capsule.	It is not differentiated in foot, seta and capsule.
Capsule often possesses elaters.	Elaters are absent.
Dehiscence occurs through elaters.	Peristome perform these functions.
A protonema stage is absent. .	A juvenile protonema stage is present.

Pteridophytes

Pteridophytes are primitive seedless vascular plants also called cryptogams. These have conspicuous sporophytic plant body, inconspicuous independent gametophytes with antheridia and partially embedded archegonia having 4-rowed necks.

The term Pteridophyte was coined by Haeckel (1866). There are about 13000 species of pteridophytes have been reported. They were perhaps the first land plants evolved during ordovician (450-500 million years ago) period.
The characteristic features of pteridophytes are as follow

Habitat
The pteridophytes are found in cool, damp shady places though some may flourish well in sandy-soil conditions.
Some members like Azolla, Salvinia, Marsilea species.

Plant Body
The size varies from a fraction of centimeter (e.g, Azolla) to 20 m in tree ferns (e.g, Angiopteris). The main plant body is a sporophyte which is differentiated into true root, stem and leaves. These organs possess well differentiated vascular

tissues. The leaves are small (microphyllus) as in Selaginella or large (macrophylls) as in ferns.

Vascular Tissues
These are xylem and phloem present throughout the body. Xylem consists of tracheids and phloem is made up of sieve cells and albuminous cells.

Sporophylls
The sporophytes bear sporangia that are subtended by leaf like appendages called sporophylls. In some cases sporophylls may form distinct compact structure called strobili or cones (Selaginella and Equisetuni). The sporangia produce spores by meiosis in spore mother cells.

Spores
The spores germinate to give rise to inconspicuous, small but multicellular free-living, mostly photosynthetic thalloid gametophytes called prothallus. In majority of the pteridophytes, all the spores are of similar kinds; such plants are called homosporous. Genera like Selaginella and Salvinia which produce two kinds of spores, macro (large) and micro (small) spores; such plants are called heterosporous.

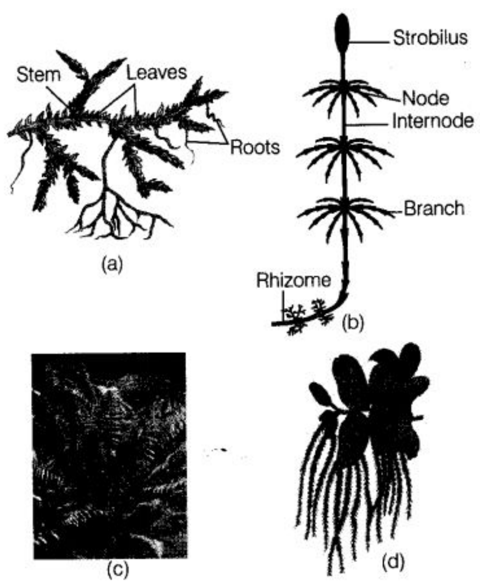


Fig 3.7 (a) *Selaginella* (b) *Equisetum* (c) Fern (d) *Salvinia*

Gametophyte
The thalloid gametophyte or prothallus require cool, damp, shady places to grow.

The megaspores and microspores germinate and give rise to female and male gametophytes respectively. The female gametophytes in these plants is retained on the parent sporophytes for viable periods. In most ferns, prothallus is green and autotrophic. In heterosporous ferns, the female gametophyte depends on food stored by the megaspore.

Sex Organs
The gametophytes bear male sex organs called antheridia and female sex organs called archegonia. Antheridium is sessile and surrounded by a single layered jacket. Archegonium is flask-shaped. It is partially embedded.

Fertilisation
Water is required for transfer of antherozoids. The male gametes released from the antheridia and reach to the mouth of archegonium. Fusion of male gamete with the egg present in the archegonium result in the formation of zygote. Zygote therefore, produces a multicellular, well differentiated sporophyte, which is the dominant phase of the pteridophytes.

Embryo
Fertilisation produces a zygote that undergoes division to produce embryo. The development of the zygote into young embryo takes place within the female gametophyte.
* This event is a precursor of the seed habit and considered as an important step in evolution, e.g., Dryopteris, Selaginella, Adiantum, Equisetum and Salvinia.

Economic Importance of Pteridophytes
(i) Pteridophytes are a good source of food for animals. For example, sporocarps of Marsilea is edible. Angiopteris and Alsophila have starchy pith eaten by natives of Australia.
(ii) Ferns protect soil from erosion by providing a good cover on the hill slopes and other fragile places.
(iii) Equisetum stems have rough surfaces. They are used in scrubbing and polishing.
(iv) Azolla a water fern has a symbiotic association with nitrogen fixing cyanobacterium Anabaena azollae. It is cultured in paddy fields to harbour nitrogen fixing bacterium. Thus, act as a biofertiliser.
(v) Rhizomes and petioles of Dryopteris are used to produce anthelmintic drug. Roots of Adiantum can cure throat infections. Lycopodium is used in treatment of

rheumatism and disorders of lungs and kidneys.
(vi) Ferns are also grown as ornamental plants for their graceful plant body.

Classification of Pteridophytes
The pteridophytes are further classified into four classes
(i) Psilopsida (Psilotum)
(ii) Lycopsida (Selaginella and Lycopodium)
(iii) Sphenopsida (Equisetum)
(iv) Pteropsida (Dryopteris, Pteris and Adiantum)

Differences between Bryophytes and Pteridophytes

Bryophytes	Pteridophytes
The main plant body is gametophyte.	It is sporophyte.
These are non-vascular plants.	These are vascular plants.
Sporophyte is parasitic over gametophyte.	Sporophyte is independent of gametophyte.
Plant body can be thallus or foliose.	It is differentiated into stem, leaves and roots.
True stems and leaves are not present.	It has true stems and leaves.
Roots are absent, rhizoids are present.	Roots are present.
Sex organs are stalked.	Sex organs are sessile.
The wall of archegonial neck is 5-6 rowed.	The wall of archegonial neck is 4-rowed.

2. Gymnosperms, Angiosperms and Plant Life Cycles

Gymnosperms
The gymnosperms (Gymnos = naked; sperma = seeds) are plants in which the ovules are not enclosed by any ovary wall and remain exposed, both before and after fertilisation. These are small groups of seed plants which are represented by only 900 living species. Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. They remain within the sporangia retained on the sporophytes.

Habitat
These plants are mostly found in colder parts of northern hemisphere, where they

form extensive forests. A number of gymnosperms are now, known as ornamentals, e.g., Ginkgo, Thuja, Araucaria, etc.

Morphology
Gymnosperms include, medium-sized trees or tall trees and shrubs. The giant red wood tree Sequoia is one of the forest tree upto 100 m. Species of Gnetum are woody climbers. The smallest gymnosperm is Zamia pygmaea which reaches a height of 25 cm. Many of the gymnosperms live for more than 4000 years, e.g, Pine (Pinus), redwood {Sequoia).

External Features
The plant body is sporophyte and differentiated into root, stem and leaves.

Plant Body
Tap roots are present for proper anchorage to heavy plant. Roots in some genera have fungal association in the form of mycorrhiza {Pinus), while in some others {Cycas) small specialised roots called coralloid roots are associated with N2-fixing cyanobacteria such as Anabaena, Nostoc, etc.
The stems are branched {Pinus, Cedrus) or unbranched {Cycas). The leaves may be simple or compound.

Archegonia
The megaspore mother cell thus, undergo meiotic division forming four megaspores. Out of which one is enclosed within the megasporangium (nucellus) and develops into a multicellular female gametophyte, bearing two or more archegonia of female sex organs.
The multicellular female gametophyte is also retained within megasporangium.

Fertilisation
Air current required for transport of male gametes. The male gametes are carried to the archegonia, i.e., gamete in the ovule by means o'f a tube called pollen tube and discharge their contents near the mouth of the archegonia. This is called siphonogamy.

Seeds
Following fertilisation, zygote develops into an embryo and the ovules into seeds. The seeds contain food laden tissue called endosperm. It lies naked or exposed.

Endosperm provides nourishment for growth of seedling at the time of seed germination.
Examples Cycas, Pinus, Ginkgo, Ephedra, Gnetum, Vaucheria, Cedrus, Abies, etc.

Differences between Microsporophyll and Megasporophyll

Microsporophyll	Megasporophyll
It bears microsporangia.	It bears megasporangia.
It contains numerous microspores.	It usually contains one megaspore.
Microspores are released.	Megaspore are retains inside the megasporangium.

Classification of Gymnosperms

Gymnospermsfurther include three main classes Cycadopsida (cycads), Coniferopsida (conifers) and Gnetopsida (Gnetum).

Differences between Male Gametophyte of Pteridophyte and Gymnosperms

Male Gametophyte of Pteridophyte Male Gametophyte of Gymnosperms
A distinct male gametophyte may not be present. A distinct male gametophyte is present.
It contains an antheridium. Antheridium is not present.
Male gametes are flagellate. Male gametes can be flagellate or non-flagellate.
Male gametes reach female gametes by swimming in water. Male gamete reach the female gamete through a pollen tube.

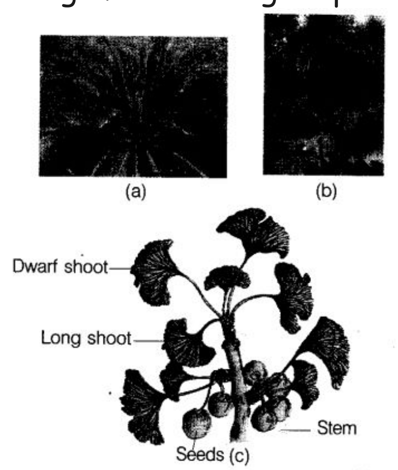


Fig. 3.8 Gymnosperms : (a) *Cycas* (b) *Pinus* (c) *Ginkgo*

Economic Importance of Gymnosperms

(i) Seeds of Pinus gerardiana (chilgoza) are used a food after roasting. Some other edible gymnosperms plant part are endosperm of Ginkgo, seed kernel of some Cycas and Gnetum, sago grains from stems of Cycas, etc.
(ii) Gymnosperms provide softwood for construction, plywood and paper industry.

(iii) Branches of gymnosperm trees are used as fuel food.
Saw dust of conifers is used in making plastics and linoleum.
Resin is a semifluid secreted by special tubes of a number of conifers. It helps in sealing female cones after pollination, scale leaves around leaf bases and apical buds. Resin is distilled to obtain turpentine and resin. Turpentine is used for . thinning paints, varnishes, etc., and resin is used
for sealing joints, wheel green, preparation of writing paper, oil clothes, etc.

(iv) Ephedrine an antibiotic is obtained from Ephedra. It is used for curing respiratory problems and asthma. Taxol is an anticancer drug obtained from Taxus.

Angiosperms
Angiosperms are seed bearing plants or flowering plants. Unlike gymnosperms where the ovules are naked, in angiosperms the sporophyll are organised into flowers and the seeds are produced inside fruits. There are about 250000 species of angiosperms in the nature. They evolved about 130-160 million years ago.

Habitat
Angiosperm are found in wide range of habitats, from the land to up to 6000 m in Himalayas or Antarctica and Tundra, dry hot deserts, cold deserts, tropics, fresh water up to 60°C, underground, over other plants as parasites, saprophyte, etc. Zostera is a marine angiosperm.

Plant Body
These plant are sporophytic, in the form of herbs, shrubs, trees, climber creepers, etc. The smallest angiosperm is water plant Wolffia and tallest is Eucalyptus regnans (100 mand above). Primary root develops from radicle. It forms tap root system. In many angiosperms roots develop from places other than radicle, these are adventitious roots. Stem develops from plumule.

Leaves
These are simple or compound. The leaves bear axillary buds which can grow into stem branches.

Vascular Tissues
Angiosperms have vessels in xylem. Phloem contains sieve tubes and companion cells in regard to gymnosperms which do not have companion cells.

Flowers
Flowers are the reproductive structures formed by the union of one or both types of sporophylls (microsporophylls or stamens and megasporophylls or carpels).

Microsporophylls or Male Sex Organs
Stamens are considered as the male sex organs of a flower. Each stamen has two main parts, i.e., a slender filament with an anther (at the tip). An anther contains four microsporangia where microspore mother cells become differentiated to form four microspores, each developing into a pollen grain.

Megasporophylls or Female Sex Organs
Carpel or pistil is called the female sex organ of the flower. Each carpel has three parts {i.e., an ovary, style and stigma). A megaspore mother cell is differentiated in the nucellus and undergoes meiosis, ultimately one functional megaspore gets enlarged and forms the female gametophyte known as embryo-sac.

Each cell of an embryo sac is haploid:
Embryo Sac
Each embryosac contains a three celled eg® apparatus consisting I of one egg cell and two synergids, three antipodal cells (at the i opposite end) and two polar nuclei (in the central cell). The polar : nuclei eventually fuses and forms diploid secondary nucleus.
Pollination
Pollen grains after dispersal from the anthers are carried by various ways such as wind, water or by various other agencies to the stigma of the pistil.

Fertilisation and Development of a Seed
Each pollen grain germinates on the stigma forming a pollen tube that carries two male gametes to the embryo sac, growing through the tissues of stigma and style. One of the male gametes fuses with the egg cell to form a zygote (syngamy).

The other male gamete fuses with the diploid secondary nucleus to produce the triploid Primary Endosperm Nucleus (PEN). Because of the involvement of above mentioned two events, it is known as double fertilisation. After fertilisation, synergids and antipodal cells degenerate.
The zygote develops into embryo and the primary endosperm nucleus develops into an endosperm.

The ovule gradually transforms into a seed and the ovary becomes the fruit. A fruit is actually a ripened ovary. They not only protect the seed but also help in their dispersal.

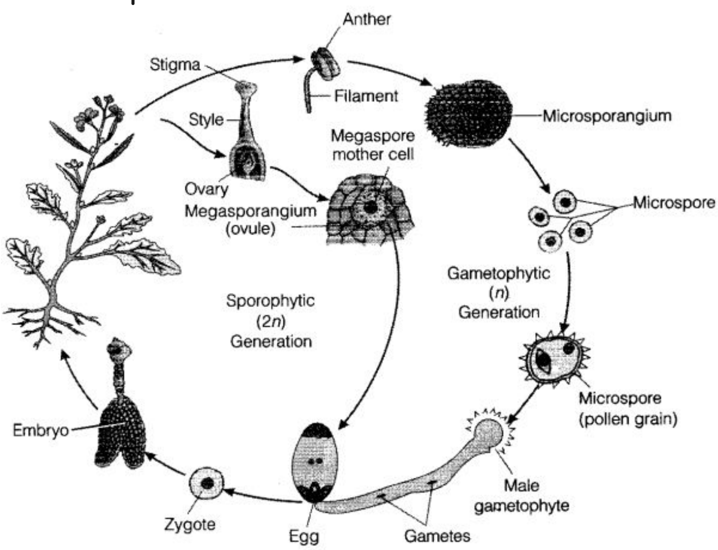


Fig. 3.9 Life cycle of an angiosperm

Differences between Gymnosperm and Angiosperm

Gymnosperms	Angiosperms
Vessels or trachea is absent in xylem.	Trachea is present in xylem.
Phloem contains sieve cells.	Phloem tissue contains sieve tube and companion cells.
Sporophyll are aggregated to form cones.	Sporophyll are aggregated to produce flowers.
Sepals and petals absent.	Sepals and petals present.
Cones are generally unisexual.	Flowers are generally bisexual.
Microsporophyll are broad and leaf like.	Microsporophyll have a stalk and terminal anthers.
Megasporophylls are woody and there is no rolling of megasporophylls.	The magasporophyll are softer and rolled into ovary, style and stigma.
Ovules are exposed.	Ovules are enclosed in ovary.
Archegonia is present	Archegonia absent.
Pollen enters micropyle directly.	Pollen germinates on stigma, pollen tube passes through style to enter ovary.
Single fertilisation.	Double fertilisation
Endosperm is haploid and formed before fertilisation.	Endosperm is triploid and formed after fertilisation.
Seeds exposed because there in no ovary, so no fruit formation.	Seed are enclosed in a fruit which forms after fertilisation.

Classification of Angiosperms

George Bentham and Joseph Dalton Hooker presented the system of classification of angiosperm* published in Genera Plantarum (1862-1883) which appeared in three

volumes.
This system of classification is used by most of the well known Herbaria of the world. The details of this system are not described here. Conveniently, on the basis of the number of cotyledons angiosperm are classified in two broad groups i.e., Monocotyledonae and Dicotyledonae.

Differences between Monocots and Dicots

Monocots	Dicots
They contain one cotyledon.	They contain two cotyledons.
Leaves have parallel venation.	Leaves have reticulate venation.
Fibrous root system is present.	Tap root system is present.
Stomata are dumb-bell shaped.	Stomata are kidney- shaped.
Vascular bundles are scattered.	Vascular bundles are arranged in rings.
Cambium is absent.	Cambium is present.
Stems do not have concentric arrangement of tissue. A ground tissue is present.	Stems have concentric arrangement of tissue epidermis cortex, endodermis, pericycle, pith, etc.
Secondary growth is absent with some exception in stems.	These show secondary growth in stem.
Root has pith in its centre.	Root is generally devoid of pith.
Secondary growth is absent in roots with some exception.	Secondary growth occurs in roots.

Economic Importance of Angiosperms
(i) The angiosperms are major source of food, fibers, spices and beverages.
(ii) They also provide valuable timber and medicines.
(iii) These also add beauty to our environment as well.

Alteration of Generation
Life cycle of an organism is a sequence of events that occur from birth to death of an organism. In plants, both haploid and diploid cells can divide by mitosis.
This feature leads to the formation of different plant bodies haploid and diploid.
The haploid plant body produces gametes by mitosis. This plant body represents a gametophyte.

After fertilization, zygote also divides by mitosis to produce a diploid saprophytic plant body. Haploid spores are produced by this plant body by meiosis. These in turn, divide by mitosis to form a haploid plant body once again.
Thus, during the life cycle of any sexually reproducing plant, there is an alternation of generation between gamete producing haploid gametophyte and spore producing diploid saprophyte.

Plant Life Cycles

Different plant groups and individual have different features in their life cycle

Haplontic

The dominant photosynthetic phase is a gametophyte produced by haploid spores.
The gametophyte produces gametes by mitosis.
The gametes fuse and produce a diploid zygote, that represents sporophytic generation. There are no free living sporophytes. Meiosis in the zygote results in formation of haploid spores. This kind of life cycle is called haplontic.
Many algae such as Volvox, Spirogyra and Chlamydomonas represent this pattern of life cycle.

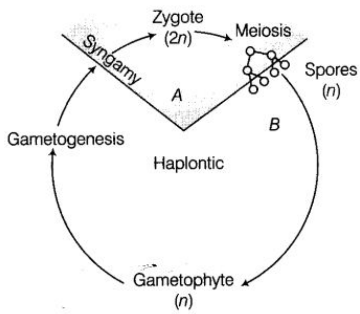


Fig. 3.10 Life cycle pattern : Haplontic

Diplontic

In this type, the diploid sporophyte is the dominant. The multicellular diploid phase is called sporophyte. The gametophytic phase is represented by the single to few celled haploid gametophyte.
This kind of life cycle is termed as diplontic. All seed bearing plants, gymnosperms and angiosperms follow this pattern of life cycle. Fucus, an alga is diplontic.

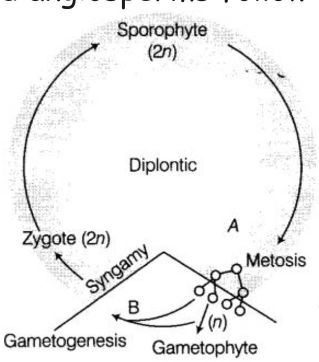


Fig. 3.11 Life cycle pattern: Diplontic

Haplodiplontic

In this type, there are two distinct multicellular phases, diploid sporophyte and haploid gametophyte are present. Both phases are multicellular. However, they dilfer in their dominant phases.

(i) A dominant, independent, photosynthetic, thalloid or erect phase is represented by a haploid gametophyte. It alternates with the short lived multicellular sporophyte totally, partially or dependent on the gametophyte for its anchorage and nutrition. All bryophytes represent this pattern.

(ii) The diploid saprophyte is represented by a dominant independent photosynthetic vascular plant body. It alternates with multicellular saprophytic/autotrophic, independent but short lived haploid gametophyte. This pattern is called haplodiplontic life cycle. All pteridophytes demonstrate this pattern. However, most algal genera are haplontic, some of them such as Ectocarpus, Polysiphonia and kelps are haplodiplontic.

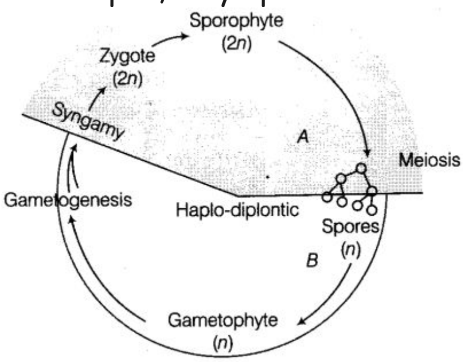


Fig. 3.12 Life cycle pattern: Haplodiplontic

Plant Kingdom Class 5 MCQs Questions with Answers

Question 1.
Rhodophyceae is called red algae because of the pigment
(a) Fucoxanthin
(b) Phycoerythrin
(c) Carotenoids
(d) Chlorophyll c
Answer
Answer: (b) Phycoerythrin
Explanation:
Members of Rhodophyceae are commonly called red algae because of the predominance of the red pigment, r-phycoerythrin in their body.

Question 2.
Which of the followings plant material is an efficient water imbibant?
(a) Agar
(b) Cellulose

(c) Lignin
(d) Pectin
Answer
Answer: (a) Agar

Question 3.
In a monoecious plant
(a) Male and female sex organs are on the same individual
(b) Male and female gametes are of two morphologically distinct types
(c) Male and female sex organs are on different individuals
(d) All the stamens are fused to form one unit
Answer
Answer: (a) Male and female sex organs are on the same individual

Question 4.
The seedless vascular plants whose sporophytes are larger than their small and independent gametophytes are
(a) Pteridophytes
(b) Angiosperms
(c) Gymnosperms
(d) None of these
Answer
Answer: (a) Pteridophytes

Question 5.
Which of the following is a liverwort?
(a) Sphagnum
(b) Funaria
(c) Marchantia
(d) Polytrichum
Answer
Answer: (c) Marchantia
Explanation:
Marchantia is a liverwort.
Sphagnum, Funaria and Polytrichum are mosses.

Question 6.
Transgenic plants are the ones

(a) Grown in artificial medium after hybridization in the field
(b) Produced by a somatic embryo in artificial medium
(c) Generated by introducing foreign DNA in to a cell and regenerating a plant from that cell
(d) Produced after protoplast fusion in artificial medium
Answer
Answer: (c) Generated by introducing foreign DNA in to a cell and regenerating a plant from that cell

Question 7.
Which of the following plants is used extensively for the study of photosynthesis?
(a) Amaranthus
(b) Asparagus
(c) Chlorella
(d) Sunflower
Answer
Answer: (c) Chlorella

Question 8.
Which of the following is used to grow microbes?
(a) Laminaria
(b) Gelidium
(c) Chlorella
(d) Sargassum
Answer
Answer: (b) Gelidium
Explanation:
Agar is extracted from Gelidium and Gracilaria, it is used to grow microbes and in preparation of ice-cream and jellies.

Question 9.
Isogamous condition with non-flagellated gametes is found in
(a) Chlamydomonas
(b) Spirogyra
(c) Volvox
(d) Fucus
Answer
Answer: (b) Spirogyra

Question 10.
Gymnosperms produce neither flower nor fruit because they do not possess
(a) Embryo
(b) Ovary
(c) Ovule
(d) Seed
Answer
Answer: (b) Ovary

Question 11.
Rhodophyceae is called red algae because of the pigment
(a) Fucoxanthin
(b) Phycoerythrin
(c) Carotenoids
(d) Chlorophyll c
Answer
Answer: (b) Phycoerythrin
Explanation:
Members of Rhodophyceae are commonly called red algae because of the predominance of the red pigment, r-phycoerythrin in their body.

Question 12.
In moss stomata appears on
(a) Capsule
(b) Leaves
(c) Stem
(d) All of these
Answer
Answer: (a) Capsule

Question 13.
The gametophyte is not an independent, free-living generation in
(a) Pinus
(b) Polytrichum
(c) Adiantum
(d) Marchantia
Answer

Answer: (a) Pinus

Question 14.
In gymnosperms, the development of pollen grains occurs in
(a) Strobili
(b) Microsporangia
(c) Megasporangia
(d) Macrosporangia
Answer
Answer: (b) Microsporangia
Explanation:
In gymnosperms, the development of pollen grains occur in microsporangia.

Question 15.
Ribbon shaped chloroplasts occur in
(a) Ulothrix
(b) Spirogyra
(c) Chlamydomonas
(d) Riccia
Answer
Answer: (b) Spirogyra

Question 16.
Antheridia and Archegonia are sex organs of
(a) Moss
(b) Mucor
(c) Spirogyra
(d) Puccinia
Answer
Answer: (a) Moss

Question 17.
Iodine is found in
(a) Spirogyra
(b) Laminaria
(c) Polysiphonia
(d) Chlorella
Answer

Answer: (b) Laminaria

Question 18.
Bryophytes are called amphibians of plant kingdom because
(a) These plants live in soil and depend on marine organisms for asexual reproduction.
(b) These plants live in soil and depend on water for sexual reproduction.
(c) These plants live in water and depend on land animals for sexual reproduction.
(d) These plants live near water bodies.
Answer
Answer: (b) These plants live in soil and depend on water for sexual reproduction.
Explanation:
Bryophytes are called amphibians of plant Kingdom because they live in soil and depend on water for sexual reproduction.
They usually occur in damp humid and shaded areas.

Question 19.
Which one of the following is a vascular cryptogram?
(a) Cedrus
(b) Equisetum
(c) Ginkgo
(d) Marchantia
Answer
Answer: (b) Equisetum

Question 20.
Pinus differs from mango in having
(a) Tree habit
(b) Green leaves
(c) Ovules not enclosed in ovary
(d) Wood
Answer
Answer: (c) Ovules not enclosed in ovary

Animal Kingdom Class 5 Notes Biology Chapter 4

here are over a million species of animals that have been described till now. These vast pecies have diverse structural forms. Therefore, the need for classification of animals ecomes very important.

Animals : Features & Basis of Classification

he classification helps in easy identification and also in assigning a systematic position t ewly described species.
n spite of differences in structure and form of different animals, there are fundament eatures common to various individuals in relation to the arrangement of cells, body ymmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems. hese features are used as the basis of animal classification.

evels of Organisation
ll members of Animalia are multicellular, heterotrophic eukaryotes. But, all of them do ot exhibit the same pattern of organisation of cells. The cells in their body are of sever ypes. These are organised into several functional units of progressively increasing omplexity.
he animal body shows four basic levels of structural organisation as given below

. Cellular Level
n this level, the body shows some division of labour among cells. They are remarkably dependent and can change their form and function. It is found in sponges. The body onsists of many cells arranged as loose cell aggregates but, the cells do not form tissue

. Tissue Level
ere, in coelenterates, the arrangement of cells is more complex. The cells performing t ame function are arranged into tissues, hence is called tissue level of organisation.

. **Organ Level**

n Platyhelminthes and other higher phyla, tissues are grouped together to form organs, ach specialised for a particular function, i.e., organ level organisation is present.

. **Organ System Level**

n animals like annelids, arthropods, molluscs, echinoderms and chordates, organs have ssociated to form functional systems, each system concerned with a specific physiologi unction. This is called organ system level of organisation. Organ systems in different roups of animals exhibit various patterns of complexities.

ike the digestive system in Platyhelminthes has only a single opening to the outside of t ody that serves as both mouth and anus and is thus, called incomplete.

 complete digestive system has two openings, i.e., mouth and anus.

ymmetry

he symmetry refers to the arrangement of parts on the opposite sides of the body of a hree dimensional animal.

n the basis of symmetry, animals can be of following types

. **Asymmetrical**

nimals in which, any plane passes through the center does not divide them into equal alves such animals are called asymmetrical, e.g., Sponges.

. **Symmetrical**

he body of some animals can be divided into two similar equal halves by one or more lanes. Such animals are called symmetrical.

he symmetry can be further divided as

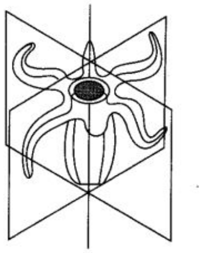
 Radial Symmetry

/hen any plane passing through the central axis of the body divides the organism into tw lentical halves, it is called radial symmetry, e.g., Coelenterates, ctenophores and chinoderms.

. **Bilateral Symmetry**

n some animals, body can be divided into identical left and right halves in only one plane.

his is called bilateral symmetry, e.g., Annelids, arthropods, etc.



ig. 4.1 Radial symmetry

iploblastic and Triploblastic Organisation

erm layers are group of cells behaving as a unit during early stages of embryonic evelopment. It differentiate to give rise to all the tissues/organs of the fully formed dividuals.

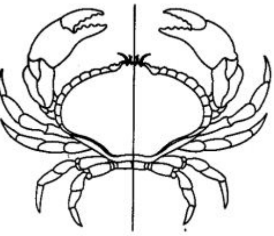


Fig. 4.2 Bilateral symmetry

n the basis of germ layers animals are classified as follows

. Diploblastic

nimals in which the cells are arranged in two embryonic layers—an external ectoderm a n internal endoderm, are called diploblastic animals. In addition, an undifferentiated yer, mesoglea is present in between the ectoderm and the endoderm. e.g., Coelenterate

. Triploblastic

he animals in which the developing embryo has a third germinal layer mesoderm, in etween the ectoderm and endoderm are called triploblastic animals, e.g., All animals fro hylum-Platyhelminthes to phylum-Chordata.

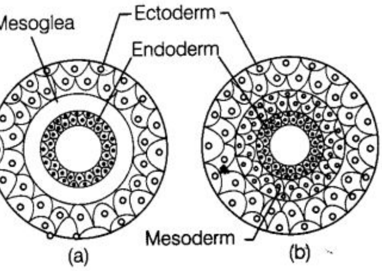


Fig. 4.3 Showing germinal layers

oelom

he body cavity (between the body wall and gut wall) which is lined by mesoderm is callec oelom. The presence or absence of coelom is very important in classification. On the bas f coelom, animals can be classified in three different groups

. **Acoelomates**

he animals in which the body cavity is absent are called acoelomates, e.g., Poriferans, atyhelminthes, coelenterates, ctenophors and flatworms.

. **Pseudocoelomates**

n some animals, the body cavity is not lined by mesoderm. Instead, the mesoderm is resent as scattered pouches in between the ectoderm and endoderm. Such a . body cavi called pseudocoelom and the animals possessing them are called pseudocoelomates, e.g schelminthes.

. **Coelomates**

he animals having true coelom are called coelomates. A true coelom arises within esoderm and is therefore, lined by mesodermal tissues, i.e., externally by parietal eritoneum and internally by visceral peritoneum.

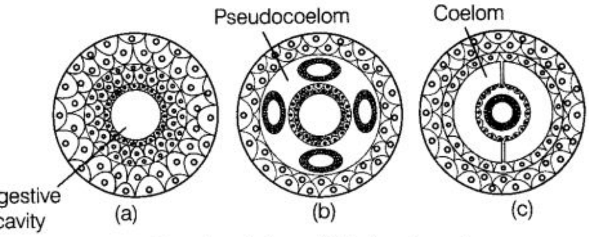


Fig. 4.4 Sectional view of (a) Acoelomates (b) Pseudocoelomate and (c) Eucoelomate

ody Plan

nimals have three types of body plans. These are

Animals

ell Aggregate Plan
cluster of cells
th a limited divis-
n of labour in which
ssues or organs are
osent.
ample Sponges.

Blind Sac Body Plan
Cells are organised into tissues. There is division of labour and each tissue performs a specific task.
Single opening of the body for ingestion and egestion.
Example Coelenterates, flatworms, ctenophores.

Tube within Tube Plan
Level of organisation is organ system, Proper digestive canal is present, having two openings, *i.e,* one for ingestion and other for egestion.
Example Aschelminthes.

The body plans of all higher invertebrates and vertebrates cannot be described due to increase in their body complexity. *However, o. the basis of their development from blastopore, these can be classified as*

Protostomes
Mouth develops from blastopore region and anus develops later.
Example Annelida, mollusca, arthropoda and roundworms.

Deuterostomes
Anus develops first from blastopore region and mouth develops later.
Example Echinoderms and chordates.

egmentation

n some animals, the body is externally and internally divided into segments or somites ith a serial repetition of at least some organs.

egmentation can be of following two types

. Metameric Segmentation

segmentation that simultaneously divides body both externally and internally is called etamerism or metameric segmentation. This kind of segmentation is found in annelids, rthropods and chordates.

. Pseudometamerism

t is found in tapeworm, the body is divisible into parts or segments called proglottides. hey develop from the neck but are not embryonic in or T n r a repetition which appears ue to repeated budding As known as false segmentation or pseudometamerism.

lotochord

t is a mesodermally derived rod-like structure formed on the dorsal side during mbryonic development in some animals.
nimals with notochord are called chordates and those animals which do not form this ructure are called non-chordates, e.g., Porifera to echinoderms.

ther Important Features

part from the basic features of body, size and shape, animals also possess some other nportant features too.

ome of them are given below

. Cephalisation

t is the differentiation of head in anterior part of the body. It involves the concentrat f nervous tissue and sense organs in the head.

. Appendages

he projecting structures of the body that perform specific functions like locomotion, apturing of food, sensation, etc., are called appendages, eg., Wings, fins, limbs, tentacle arapodia, setae, etc.

. Digestive System

igestive tract is the passage through which food is taken for digestion, absorption and gestion. The digestive tract that has a single opening for both ingestion and egestion is alled incomplete digestive tract, eg., in flatwprms and coelenterates.

he digestive tract with two external openings, one for ingestion and other for egestion alled complete digestive tract. It is present in aschelminthes and higher animals.

. Respiratory System

espiration occurs in different ways in different animals

) The tiny aquatic animals like Amoeba, Hydra, etc., respire through the body surface. his is called body surface respiration.

i) Larger aquatic animals have special organs called gills for respiration. This is called ranchial respiration, eg., In prawns, fishes and mussels.

ii) The land animals respire through lungs. This is called pulmonary respiration. It occur frogs, snails, lizards, birds and mammals.

v) Insects have tracheal respiration, which occurs through trachea i.e. an tercommunicating tubes through which gas exchange occurs.

) In animals like earthworm, leech, frogs etc., moist skin acts as respiratory surface. his is called cutaneous respiration.

i) Scorpions have book lungs and king crabs have book gills for respiration.

ii) In frog, gas exchange also occurs through the lining of buccopharyngeal cavity. Henc alled buccopharyngeal respiration.

rogs have three modes of respiration, i. e., Cutaneous, buccopharyngeal and pulmonary.

. Circulatory System

he circulatory system is responsible for the transport of materials in the body. It onsists of a fluid (called blood) blood vessels and a heart.

he circulatory system is closed when blood flows within the blood vessels.

f blood flows in spaces, and the sinuses are without proper boundries, the circulatory ystem is called open. In insects such as prawn and Pila, blood is colourless that contains aemocyanin (a copper containing pigment) while, in vertebrates, blood contains aemoglobin (an iron-containing pigment).

. Excretory System

xcretory system is involved in the removal of nitrogenous waste products from the bod f an organism with the help of excretory organs.

he excretion occurs in different ways in different organisms. Such as

) The excretory organs are absent in those organisms where organisation level is below he tissue level. Here, each individual cell takes part in excretion.

i) In animals like sponges, coelenterates, all the cells are in contact with water. Excreti ccur by general body surface.

ii) In vertebrates, kidneys are the excretory organs. Based on excretory products nimals can be classified into four categories as given below

) Aminotelic, excretory product is amino acids, e.g., Starfish, Unio,'etc.

i) Ammonotelic, excretory product is ammonia, e.g, most invertebrates and some mollusc

ii) Ureotelic, excretory product is urea, e.g., Cartilaginous fishes, snail, prawn, mammals nd aquatic reptiles.

v) Uricotelic, excretory product is uric acid, e.g, Insects, terrestrial crustaceans, lizar nakes, birds etc.

. Nervous System

he nervous system is the aggregation of nerve cells that help in coordinating and ontrolling various activities of the body.

. Endocrine System

he endocrine glands are also called ductless glands. These secrete hormones. Endocrine lands occur in all vertebrates and in some invertebrates (like insects).

. Sensory System

his system consists of specialised cells, tissues and organs which can pick up a stimulus nd transmit the same to the nervous system.

ensory system consists of different structures in different organisms, e.g., Antennal actile and smell), tentacles (tactile), skin (tactile), statocyst (balancing), ear (hearing), factory epithelium (smell), taste buds (taste), eyes (vision), lateral line organs (current eceptors), etc.

0. Skeletal System

keletal system is a hard, internal or external framework • that provides support and hape to the body. Some animals which are devoid of a skeleton have soft body, e.g., atyhelminthes, aschelminthes, annelida.

keleton system can be of following types

Exoskeleton

t is the hard supporting and protective framework present on exterior of the body. It i ade of non-living matter, e.g., External shells of molluscs, cuticle of arthropods, scales shes and reptiles, feathers of birds, hair, hoofs, nails, horns and claws of mammals.

. Endoskeleton

t is a hard supporting framework present in the interior of the body. In invertebrates uch as sponges, it is made up of calcareous or siliceous spicules. In vertebrates, it is omposed of hard living tissues called cartilages and bones. Endoskeleton supports whole ody of an organism.

ote:

Nervous system was first formed in cnidarians.
Ascaris and earthworm are both ammonotelic and ureotelic.
Development of living and growing endoskeleton in vertebrates has enabled them to ttain large size.

1. Sex

nimals generally have sex organs to produce sexual reproduction. When both male and emale sex organs are found in some individual, it is called hermaphrodite or bisexual or onoecious, e.g, Liver fluke, tapeworm, earthworm, leech, etc.
he animals with either female or male sex organ is known as unisexual or dioecious, e.g., rog, lizards, birds, dog, etc. When male and female can be distinguished on the basis of xternal features, the condition is called sexual dimorphism, e.g., Lion and lioness, man ar omen, peacock and peahen, etc.

2. Reproduction

eproduction in organisms can be either asexual or sexual.

Asexual Reproduction

his kind of reproduction does not involve fusion of gametes. It is found in lower animals ke sponges, coelenterates, annelids, platyhelminthes. The common methods are budding ssion, fragmentation and regeneration.

- Sexual Reproduction

t involves formation and fusion of gametes. The male gametes called sperms are motile hile, the female gametes called ova are generally non-motile.

3. Fertilisation

ertilisation in animals is of two types

External Fertilisation

nimals such as many invertebrates, some marine fishes and most amphibians, shed both ggs and sperms into water, where fertilisation and development occur. This is called xternal fertilisation.

. Internal Fertilisation

n land animals and some aquatic animals, the sperms are introduced by the male into eproductive tract of female during copulation. This is called internal fertilisation. ertilisation occurs in the genital organs of the female.

viparous and Viviparous Animals

ll the animals with external fertilisation and many with internal fertilisation, such as eptiles and birds, lay eggs. They are called oviparous animals.

ome animals with internal fertilisation give birth to young ones.

uch animals are of two typesOvoviviparous animals produce large, heavily yolky eggs tha evelop in the reproductive tract of the mother without deriving nourishment from her, g., Rattle snake, sharks, etc.

iviparous animals produce minute eggs and the embryos are nourished during developme the mother's genital tract, e.g., Mammals.

n oviparous animals the newly hatched young one, may resemble the adult. This kind of evelopment is called direct development. In some animals, the young hatching from eggs o not resemble the adult. These are called larvae or nymph.

rvae lead independent life for sometime and later undergo important changes to becom dults. These changes from larvae to adults are called metamorphosis. This kind of evelopment is called indirect development.

. Non-Chordata

he animal kingdom includes about 35 phyla, of which 11 are considered as major phyla. nimals can be classified in two major groups on the basis of presence or absence of otochord. They are

) Non-chordata (absence of notochord)

i) Chordata (presence of notochord)

hey can also be classified on the basis of presence or absence of vertebral column

backbone) into
) Invertebrates (without backbone)
i) Vertebrates (with backbone)
he Non-chordata includes the following phylums(Phylum Porifera)
hylum—Porifera (Porous — pore; ferre — to bear) includes the first and the most rimitive group of multicellular animals, referred to as poriferans, i.e., pore bearing nimals. They are primitive, multicellular animals and are commonly called sponges.

eneral Features

ome general features of phylum-Porifera are discussed below

Habitat They are mostly marine and some are freshwater habitat, found in ponds" and kes, e.g., Spongilla.

he study of poriferans is called Parazoology. Even though they are multicellular, they d ot have tissue grade of organisation.

Shape and Size The size of sponges ranges from 1 cm to 1 m in length. Some of them ave vase like cylindrical shape and majority have irregular shape.

. Symmetry The cylindrical form (e.g., Sycon) show radial symmetry while, sponges owing irregular shape and have no symmetry.

. Body Wall The body wall contains outer dermal layer or pinacoderm and inner gastral yer or choanoderm.

The pinacoderm contains flat cells called pinacocytes.

The choanoderm consists of spherical cells with collar from which a flaglum emerges o ence, they are also called flagellated cells or collar cells.

Body Organisation Sponges show cellular level of organisation. The cells are almost dependent, i.e., cooperating very little with one another in function.

. Germ Layers These are diploblastic.

i. Body Cavty The sponges have a large cavity called spongocoel or paragastric cavity. It pens to the outside by a terminal opening called osculum.

ii. Skeleton It is internal and includes inorganic spicules and organic spongin fibres.

. Canal System It is one of the most important feature of sponges. Canal system is the etwork of channels called canals, which connect the spongocoel to the outside through stia. The canals are lined by choanocytes. It maintains a constant flow of water from stia to osculum through spongocoel. It helps in nutrition, respiration, reproduction and xcretion.

he canal system is the lifeline of the sponges.

Digestion Digestion in animals of this phylum is intracellular (inside collar cells) in

ature.
. Circulation The amoeboid cells transport food from ingesting cells to other cells.
i. Respiration It occurs through the body surface by diffusion.
ii. Excretion It also occurs through the body surface by diffusion in the form of
mmonia.
v. Sensory System Sponges lack sensory and nerve cells, so they are poor in response t
imuli.
v. Reproduction Sponges reproduce both asexually and sexually. Asexual reproduction
ccurs by budding or gemmules or internal buds.

exual reproduction involves the fusion of ova and spermatozoa.
vi. Fertilisation and Development
ertilisation is internal i.e., sperms of one sponge are carried by water current to the ov
f another sponge for in situ fertilisation. Development is mostly indirect with larval
ages called parenchymula (Leucosolenia) or amphiblastula(Sycon).

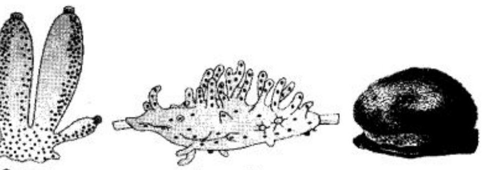


Fig. 4.5 Some examples of different sponges

lass Common Name of Some Sponges

Biological Name	Common Name
Sycon	Crown sponge
Spongilla	Freshwater sponge
Euplectella	Venus flower basket
Euspongia	Bath sponge
Cliona	Boring sponge
Pheronema	Bowl sponge
Haliclona	Finger sponge

. Dhylum Coetentcrata (Cnidana)

here are about 9000 species of cnidarians. The name Cnidaria (Knide — nettle or sting
ells) is derived from the stinging cell or cnidoblasts present on the ectoderm of tentacl
nd body of these animals.

eneral Features

ome important general features of phylum coelen- terata are discussed below

Habit and Habitat Cnidarians are exclusively of marine forms (Obelia, Aurelia, Physalia etridium), but few of them are freshwater form (e.g. Hydra). They are either sedentar fixed) or free swimming forms.

Body Organisation and Body Wall They have tissue grade organisation. Coelenterates ar iploblastic. The layers of body wall contain several types of cells, such as interestitial ells, sensory cells, nerve cells, epitheliomuscular cells, stinging cells (cnidoblasts), etc.

. Coelentric Cavity A coelenteron or gastro- vascular cavity is present, which is blind at ne end and opens as mouth or hypostome at other end. Mouth is used both for ingestion nd egestion.

. Tentacles The mouth is surrounded by many thin, long, slender hollow structures calle entacles. Their function is to paralyse and capture the prey, attachment, defense and ffence.

Skeleton A horny or calcareous exoskeleton as well as endoskeleton is present in many ases. The coelenterate with exoskeleton of calcium carbonate are called corals.

. Digestion In coelenteron or gastrovascular cavity, both intracellular and extracellular igestion occurs.
i. Respiration and Excretion Exchange of gases and excretion occurs directly as all the ells are in direct contact with water.

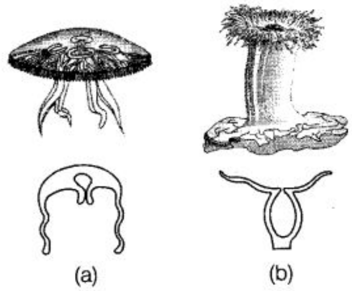
ii.Sensation Sensory cells occur in the body wall such as statocyst for balancing and oce or photosensitivity.
. Nervous System It is in the form of a nerve net, i.e., the unipolar neurons are loosely rranged in the body wall.

Polymorphism Cnidarians are mainly of two types of individuals, i.e., polyp (cup-shaped) nd medusa (umbrella-shaped). Polyp is sessile, cylindrical structure with mouth and entacles facing upwards, e.g., Hydra, Adamsia, etc. Medusa is free swimming zooid with outh and tentacles facing downwards, e.g., Aurelia or jelly fish. Medusae may form poly fter sexual reproduction while polyps form medusae through vegetative budding. Many ariations occur in zooid forms. This phenomenon is called polymorphism, which helps in ivision of labour.

. Reproduction Coelenterates reproduce both by asexual and sexual methods. In many nidarians, the polyps usually reproduce asexually by budding to give rise to a medusae. he medusae bear gonads or sex organs and reproduce sexually to form polyps.

i. Fertilisation It may be external or internal.

ii. Alternation of Generation The cnidarians complete their life cycle through two phas
e., asexually reproducing polyp phase and' sexually reproducing medusa phase. Those
nidarians which exist in both forms exhibit alternation of generation (metagenesis).



ig. 4.6 Some examples of coelenterata indicating outline of their body form (a) *Aurelia* (Medusa) (b) *Adamsia* (Polyp)

dvancement Over Sponges

he cnidarians or coelenterates exhibit advancement over sponges, as they possess a
ssue level of organisation of the body with well defined layers of cells and a digestive
avity.

ome Common Coelenterates, their Common and Zoological Names

Zoological Name	Common Name
Velella	Sail by the wind
Aurelia	Jellyfish
Fungia	Mushroom coral
Adamsia	Sea anemone
Gorgonia	Sea fan
Tubipora	Organ pipe coral
Madrepora	Stag horn coral
Physalia	Portuguese man of war
Obelia	Sea fur
Alcyonium	Dead man's finger

. Phylum Ctenophora

hylum-Ctenophora (Ktene—comb; phors—bearing) or comb jellies or sea walnuts are
xclusively marine forms. The term 'Ctenophora' was coined by Georges Cuvier. It include
bout 50 species.

eneral Features important general features 'phylum—ctenophora are below

Habitat and Habit These are of exclusively marine forms. They are found solitary;
elagic or free swimming.

Body Organisation They are diploblastic, acoe- lomate with tissue grade of organisatio
ody is soft, delicate, transparent and gelatinous, like jelly fishes without segmentation.

. Body Symmetry They are biradially symmetri-cal. The arrangement of comb plates giv
ne appearance of radial symmetry, the tentacles and branching of gastrovascular canals
how bilateral symmetry.
. Digestive System Digestion is both extra cellular and intracellular. Skeletal, circulato
espiratory and excretory systems are absent.

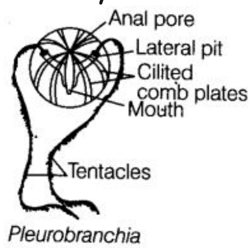


Fig. 4.7 Example of Ctenophora

Respiration and Excretion These process occur through general body surface.
. Nervous System It consists of nerve cells with an aboral sense organ called statocyst
or balance.
i. Reproduction and Development They are hermaphrodite or monoecious. Gonads are
ndodermal. Fertilisation is generally external. Development is indirect. e.g., Ctenophora,
eurobranchia.
ioluminescence (the property of a living organism to emit light) is well marked in
tenophores.

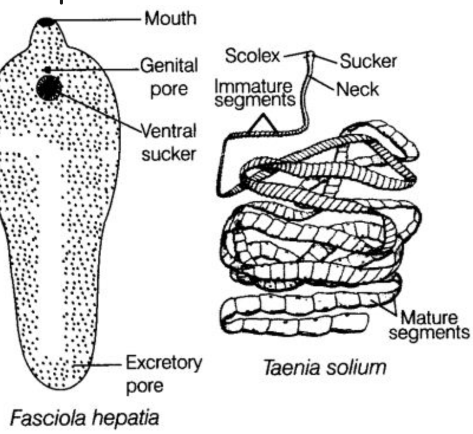


Fig. 4.8 Some examples of Platyhelminthes

.Phylum—Platyhelminthes

hylum—Platyhelminthes (Platy — flat; helminth — worm) include flatworms. The group
clude the first simplest triploblastic group of animals. Gegenbaur coined the term
latyhelminthes'. It includes about 12,000 species of animals. They have leaf like or ribb
ke body.

eneral Features

ome important general features of phylum-platyhelminthes are discussed below
Habit and Habitat Majority of forms are parasitic (tapeworms, liver flukes, blood
ukes), etc., and free-living forms (planarians). Hooks and suckers are present in parasit

orms.
Symmetry The body is bilaterally symmetrical with definite orientation like anterior a
osterior end.
. Cephalisation Primitive cephalisation is present in free-living flatworms.
. Germ Layers They are triploblastic.
Body Cavity They are acoelomate. The space between the body wall and body organ is
lled by characteristic connective tissue called parenchyme or mesenchyme.
. Body Organisation They show organ system grade of organisation.
i. Digestive System It is simple and incomplete with only one opening called mouth. The
nus is absent.
ii. Respiration It occurs through general body surface.
. Excretory System It consists of peculiar flame cells that can help in osmoregulation
nd excretion. Circulatory and skeletal systems are absent in Platyhelminthes.
Nervous System It is ladder-like and consists of a brain and two main longitudinal nerv
ords jointed at intervals by the transverse commissres.
. Reproduction Flatworms are hermaphrodite, monoecious or bisexual, having both male
nd female reproductive system. Fertilisation often includes one or more larval stages.
ome also can regenerate, e.g., Planaria, Taenia (tapeworm) and Echinococcus (dog
apeworm).

. Phylum Aschelminthes

hylum—Aschelminthes or Nemathelminthes or Nematoda (Nema — thread; helminth —
orms) includes roundworms. They are commonly called as nematodes.

eneral Feature

ome important general features of phylum- aschelminthes are discussed below
Habitat and Habit They are mostly free living and may occur in water or within the soil
here are several parasitic species which live within the body of animals or plants, e.g.,
uinea worms, whipworms, eyeworms, etc.
Symmetry They show bilateral symmetry and have organ system level of organisation.
. Germ Layers They are triploblastic animals and have tube within tube body plan.
. Body Walt The body wall contains an outer cuticle, syncytial epidermis and a muscle
yer. Circular muscles are absent.
Body Cavity Aschelminthes are pseudocoelomates as the cavity present between the
ody wall and gut is not lined by mesodermal epithelium.
irculatory and respiratory systems are also seem to be absent in Aschelminthes.
. Digestive System Alimentary canal is complete with a well-developed muscular pharyn
i. Excretory System It consists of a pair of gland cells or intracellular canals or both.
ii. Nervous System It contains a nerve ring around the pharynx with dorsal and ventral
ngitudinal nerve cords running throughout the length of the body.

:. Reproduction Nematodes reproduce only by sexual method. Sexes are separate and xhibit sexual dimorphism. The males are generally smaller than the females to aid opulation.
 Fertilisation It is internal. The fertilised eggs develop directly or indirectly through rvae that undergo moulting and finally grow into adults.

dvancement Over Flatworms
schelminthes show advancement over flatworms as they contain complete alimentary anal and sexes are separate.

isease Caused by Aschelminthes
schelminthes may cause the following diseases in humans
) Ascaris lumbricoides or giant intestinal roundworm is an endoparasite of the small testine
f humans. It causes ascariasis.
i) Wuchereria (filaria) or filarial worm is an endoparasite in the lymphatic vessels and mph nodes of humans. It causes elephantiasis in the legs, arms, scrotum, etc.
ii) Ancyclostoma duodenale or hookworm is an endoparasite in the small intestine of umans. It causes ancylostomiasis disease.
v) Loa loa the eyeworm lives in subdermal connective tissue of man. It causes loiasis isease characterised by subcutaneous smelling mosdy around the eyes.
) Enterobius or pinworm is found in caecum, colon or vermiform appendix of humans.
i) Trichinelia or trichina worm is found in small intestine of human beings and some othe ammals like pigs, domestic animals are rodents. It causes trichinellosis.

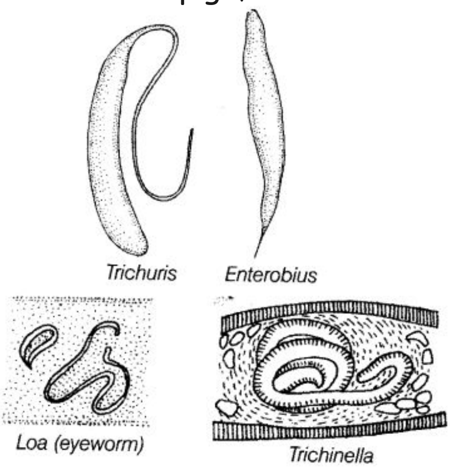


Fig. 4.9 Some examples of Aschelminthes

. Phylum Annelida
hylum—Annelida (Annulus — ring; lidos — form) includes segmented worms. The&term nnelida' was first coined by Lamarck (1809). It includes about 12,000 species of animal.

eneral Features

ome important generalfeatures of phylum- annelida are discussed below

Habit and Habitat They may be aquatic, terrestrial and free-living or parasitic.

Body Wall The outermost covering of body is thin and moist cuticle secreted by the pidermis.

. Metamerism The body is divided into segments or metameres by ring like grooves-the nnuli. It is called metameric segmentation. The segmentation is external as well as ternal.

. Symmetry Annelids are bilaterally symmetrical.

Germ Layers They are triploblastic animals.

. Organisation and Body Plan They show organ system level of organisation and tube ithin a tube body plan.

i. Cephalisation These show true cephalisation.

ii. Body Cavity Annelids have true coelom (eucoelomates). It is formed by splitting of esodermal epithelium and such a coelom is called as schizocoelom.

. Skeleton The coelomic fluid in the body cavity acts as hydrostatic skeleton for the nimal.

Locomotion Annelids move by paired, lateral, hollow, fleshy, appendages in each segme alled parapodia or chitinous setae. Aquatic annelids like Nereis possess lateral appendag hat help in swimming and have longitudinal and circular muscle for locomotion.

. Digestive System The digestive tract is straight and complete, starting from mouth a nding at anus.

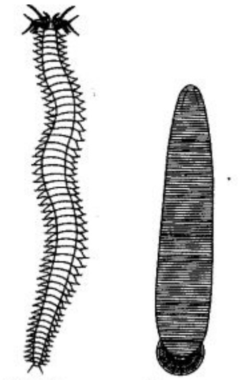
i. Respiration It occurs through skin, gills or parapodia.

ii. Circulatory System They are first animals that have a closed circulatory system, i. e he blood flows through a system of blood vessels.

xcretory System The excretory organs are nephridia in each segment, which helps xcretion and osmoregulation.

ervous System It contains a nerve ring around the pharynx and a double ventral nerve ord with ganglia.

eproduction Annelids reproduce sexually. They are unisexual, e.g., Nereis or bisexual hermaphrodite), irudinaria



g. 4.10 Some examples of Annelida

. Phylum Arthropoda

nylum-Arthropoda (Arthron – jointed; podos — foot) include the first and simplest egmented animals. These are commonly called as jointed legged animals. It is the larges roup of animal that include about 1,000,000 insect species, 1,02,248 spiders and scorpi pecies, 1,03,248 arachnoid species and 47,000 crustacean species representing about 0% of total known animal species.

eneral Features

ome important general features of phylum—arthropoda are discussed below

Habitat and Habit They may be aquatic or terrestrial. They may occur as free-living or arasitic forms e.g., Bed bugs, ticks, mosquitoes, etc.

Body Parts Body is segmented externally. It has distinct head, thorax and abdomen. ead bears many fused segments and sense organs.

. Symmetry and Body Organisation Arthropods are bilaterally symmetrical. They are riploblastic with organ system level of organisation.

. Appendages They have jointed, paired appendages, which are present in some or all omites or segments. These perform various functions like walking, clinging, jumping, eeding, etc.

Exoskeleton The exoskeleton is formed of thick, tough and non-living chitinous uticle.Exoskeleton protects animal from mechanical and chemical injuries, prevents esiccation and also helps in attachment.

. Locomotion Jointed appendages help in locomotion. Cilia are found to be absent in rthropod.

i. Digestive System Alimentary canal is complete and well-developed, i.e., divided into oregut, midgut and hindgut.

ii. Respiration It occurs through general body surface, gills (e.g., Prawn), book lungs (e.g corpion and spider), trachea (e.g., cockroach) and book gills (e.g., King crab).

ead tall Antenna

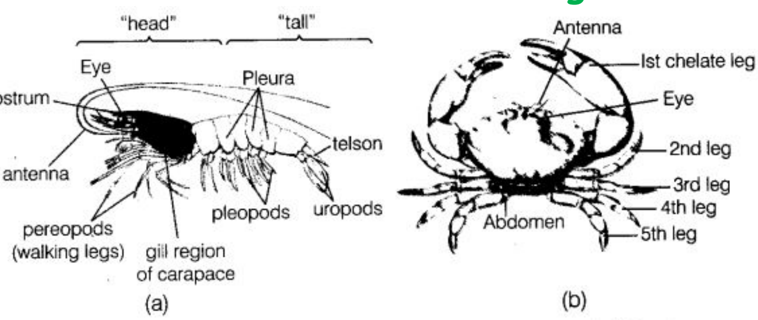


Fig. 4.11 Examples of arthropods (a) Prawn and (b) Crab

. Circulation The circulatory system is open type, i.e., blood flows in the haemocoel stead of blood vessels.

Excretion The excretory organs are Malpighian tubules (opening into duct) or green ands opening ' directly to the exterior.

. Nervous System The nervous system consists of a nerve ring and a double ganglionate entral nerve cord.

i. Sense Organs Arthropods have simple eyes called ocelli and compound eyes. Aquatic orms have statocysts for balancing.

ii. Reproduction Arthropods reproduce by sexual methods. Fertilization is usually inter ype. They are generally oviparous but few are viviparous, i.e., scorpion. Development may e direct or indirect involving metamorphosis.

dvancement Over Annelids

hey have distinct head, jointed appendages for different functions exoskeleton, specia espiratory organ, secrete pheromones and well-developed sense organs. These features re not present in annelids.

v. Classification The phylum-Arthropoda is divided into five classes Class—Crustacea, g., Palaemon (prawn), crab, etc.Class—Myriapoda, e.g., Scolopendra (centipede), Julus nillipede), etc. Insecta, Musca (homefly), Apis (honey bee), Pest-Locusta (locust), Vecto osquitoes (.Anopheles, Culex, Aedes), etc. e.g., spider, ticks, mites, Limulus (king crab),

. Phylum Mollusca

he phylum—Mollusca (Molluscs — soft bodied) includes the soft bodied, unsegmented, ucoelomate animals. These are called molluscs or shelled animals. Johnston (1650) coine he term 'Mollusca'. Molluscs is the second largest animal phylum and includes about 5,000 species.

he study of molluscs is called 'Malacology'.

eneral Features

ome important general features ofphylum—mollusca are discussed below

Habit and Habitat Molluscs are mostly of marine forms (Sepia, Octopus, Chiton, etc.)

ome are freshwater (e.g, Unio and Pila) and some are also terrestrial forms (e.g, Land nails). Few molluscs are parasites also, e.g., Glochidium larva, etc.

Symmetry These are generally bilaterally symmetrical and some are asymmetrical due orsion or twisting during growth.

. Germ Layers and Organisation They are triploblastic and possess organ system level o rganisation.

. Body Form They have unsegmented, soft body covered by a calcareous shell, which is ifferentiated into head, muscular foot and visceral hump.

antle is a soft, spongy thick fold of skin over the visceral hump that secretes calcareo hell. The space between the hump and the mantle is called the mantle cavity in which eather like gills are present.

Skeleton Molluscsgenerally have shell as exoskeleton. In Octopus, shell is absent.

. Body Cavity The coelom is greatly reduced although they are eucoelomate.

i. Locomotion The locomotory organ is muscular foot.

ii. Digestion The digestive tract is complete. The mouth contains a rasping organ called adula with file like transverse row of chitinous teeth. Anus opens into the mantle cavity

. Respiration In terrestrial forms respiration occurs through lungs. In aquatic forms, espiration occurs through feather-like gills or ctenidia.

Excretion A pair of metanephridia (kidneys) or organs of Bojanus or Keber's organs ar resent.

. Circulation Open type of circulation is present. The coelom is called haemocoel.

i. Sense Organs These have eyes, statocyst, tentacles for equilibrium and receptors fo ouch, smell and taste.

ii. Nervous System Few pairs of ganglia like cerebral, visceral and pedal with nerves is resent.

v. Reproduction Molluscs reproduce sexually. Sexes are separate and mostly oviparous. ertilisation is external or internal.

evelopment is either direct or indirect with larval stages like trochophore, glochidium c eliger. e.g., Chaetopleura(chiton), Dentalium (elephant tusk shell), Pila (apple snail), Pate plysia (sea hare). Pinctada (pearl oyster) Sepia (cuttlefish), Loligo (squid), Octopus (dev sh).

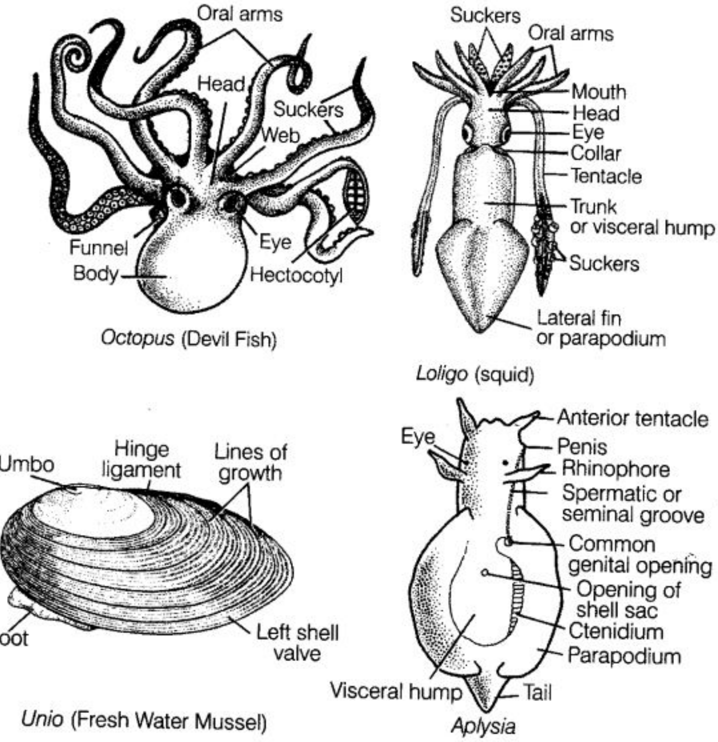


Fig. 4.12 Some examples of phylum–Mollusca

. Phylum Echinodermata

nylum—Echinodermata (Echinos—spines; derma—skin) includes the spiny skinned animals hich are exclusively marine. Jacob Klein (1734) coined the term 'Echinodermata'. It cludes about 6,000 species.

eneral Features

ome important general features of phylum—echinodermata are discussed below
Habit and Habitat These are marine forms and are bottom dwellers.
Symmetry The adults have radial (pentamerous) symmetry but, the larval forms have 'lateral symmetry.
. Germ Layers and Organisation .They are triploblastic and exhibit organ system grade rganisation.
. Head. It is absent in echinoderm and body also lacks segmentation.
Body Cavity They have true coelom, which is lined by a ciliated peritoneum. The most 'stinctive feature is the presence of water vascular system or ambulacral system with ube feet that help in locomotion, capture of food and respiration.
. Endoskeleton It contains numerous calcareous plates called ossicles beneath the skin.
i. Locomotion The locomotion is carried out by tube feet.
ii. Digestion The digestive tract is simple and complete type. The mouth is present on t wer side and the anus is on the upper side.

. Respiration It occurs through tube feet, which help in respiration.
Circulation It is reduced and open type called as haemal system.
. Excretion The excretory organs are absent. The waste products are removed by
ffusion through branchiae or amoebocytes.
i. Nervous System It contains circum-oral nerve ring, transverse and radial nerves.
ii. Reproduction Echinoderms reproduce sexually. Sexes are separate and show no sexil
morphism. Fertilisation is external and development is indirect, e.g., Asterias, (sea star
star fish), Ophiura (brittle star). Echinus (sea urchin),Cucumaria (sea cucumber),
ntedon (feather star).
phiura Asterias

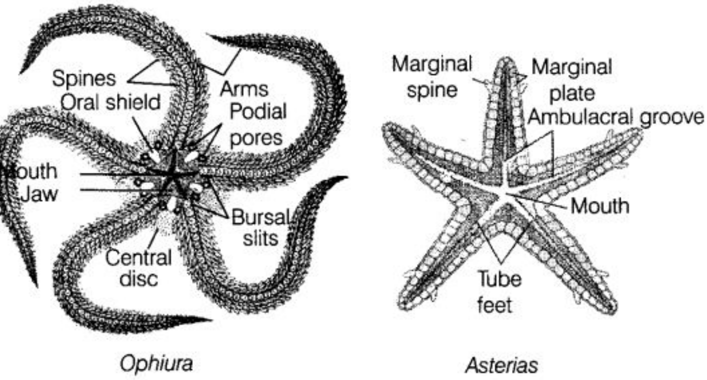


Fig. 4.13 Examples of Echinodermata

0. Phylum Hemichordata

emichordata (Hemi – half; chordata- notochord) was earlier placed as a sub-phylum und
ylum-Chordata. But, now it is considered as a separate phylum under Non-chordata.
hese are also called half chordates. This phylum consists of a small group of worm-like
imal.

eneral Features

ome important general features of phylum—hemichordata are discussed below
Habit and Habitat They are exclusive marine and mostly live in burrows.
Symmetry and Body Organisation They are bilaterally symmetrical and triploblastic.
hey have organ system level of organisation.
. Body Form They are soft-bodied, cylindrical and unsegmented body is divisible into
roboscis, collar and trunk. The body cavity is true coelom. A true notochord is absent.
. Digestive Systems Digestive system is complete.
Respiraton Respiration occurs through several pair of gill slits or through the general
ody surface.
. Circulatory System It contains a dorsal heart and is open type.
i. Excretory system It consists of proboscis gland.
ii. Nervous system It is primitive, consists mainly of an intraepidermal nerve plexus.
. Sensation Sensory cells of the epidermis act as sense organs.

Reproduction It is mostly sexual. Sexes are separate. Development is indirect with ornaria larva.

ub-phylum-Hemiehordata is the connecting link between echinoderms and chordates. g., Balanoglossus (acorn or tongue worm), Saccoglossus, Cephalodiscus, etc.

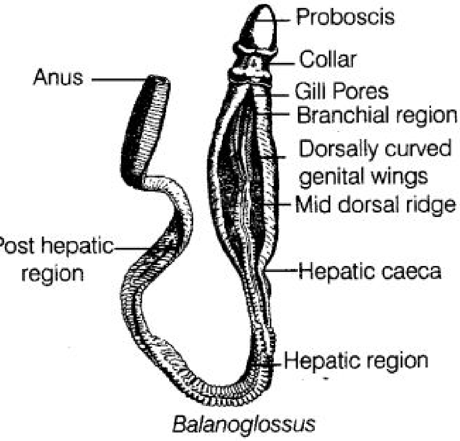


Fig.4.14 Example of Hemichordata

nimal Kingdom Class 11 MCQs Questions with Answers

uestion 1.
adula is found in
) Pila sp.
) Chiton sp.
) Lamellidens sp.
) Pinctada sp.
nswer
nswer: (a) Pila sp.

uestion 2.
harks, skates, and rays are also called _______ fishes.
) Jawless
) Bony
) Cartilaginous
) Freshwater
nswer
nswer: (c) Cartilaginous
uestion 3.
urtles are
) Arthropods
) Pisces

:) Reptiles
l) Molluscs
nswer
nswer: (c) Reptiles
uestion 4.
he clam nervous system is composed of
) labial palps
) one pair of ganglia
:) two pairs of ganglia
l) three pairs of ganglia
nswer
nswer: (d) three pairs of ganglia
uestion 5.
hoose the correct pair.
) Hippocampus – 3-chambered heart
) Rana – 2-chambered heart
:) Crocodilus – 4-chambered heart
l) Pavo – 3-chambered heart
nswer
nswer: (c) Crocodilus – 4-chambered heart
xplanation:
ippocampus (sea horse) belongs to class osteichthyes. It has 2-chambered heart (one uricle and one ventricle).
ana (frog) belongs to class amphibia. It has a 3-chambered heart (two auricles and one entricle).
rocodilus (crocodile) belongs to class reptilia. It is an exception in reptiles.
avo (peacock) belongs to class aves. It has 4-chambered heart.
uestion 6.
/ho wrote the book Systema Naturae?
) Lamarck
) Darwin
:) Wallace
l) Linnaeus
nswer
nswer: (d) Linnaeus
uestion 7.
/hich of the following statement is correct?
) Platypus lays eggs
) Camels have biconcave RBCs

c) Whales respire by gills
d) Bats do not fly
nswer
nswer: (a) Platypus lays eggs
uestion 8.
steichthyes belongs to
) class amphibia
) super class pisces
) super class tetrapoda
) division agnatha
nswer
nswer: (b) super class pisces
uestion 9.
/hich one of the following groups of animals is correctly matched with its one
haracteristic feature without even a single exception?
) Mammalia : give birth to young ones
) Reptilia : possess 3-chambered heart with one incompletely divided ventricle
) Chordata : possess a mouth provided with an upper and a lower jaw
) Chondrichthyes : possess cartilaginous endoskeleton
nswer
nswer: (d) Chondrichthyes : possess cartilaginous endoskeleton
uestion 10.
/hich one of the following phylum is characterized by absence of true coelom?
) Annelida
) Mollusca
) Echinodermata
) Nematoda
nswer
nswer: (d) Nematoda
uestion 11.
/hich of the following is a pseudocoelomate?
) Platyhelminthes
) Aschelminthes
) Mollusca
) Hemi-chordates
nswer
nswer: (b) Aschelminthes
xplanation:
schelminthes is a pseudocoelomate.

uestion 12.
/hich kind of symmetry occurs in sea anemone?
) Bilateral
) Radial
) Asymmetry
) None of these
nswer
nswer: (b) Radial
uestion 13.
hylum that doesnt have a true coelom is
) Platyhelminthes
) Annelida
) Echinoderms
) Arthropoda
nswer
nswer: (a) Platyhelminthes

uestion 14.
ale mosquitoes usually feed on
) Garbage
) Human blood
) Flower sap
) All of the above
nswer
nswer: (c) Flower sap

uestion 15.
ed Bugs contribute to the spread of
) Typhoid
) Yellow fever
) Typhus
) Trench fever
nswer
nswer: (c) Typhus

uestion 16.
/hich one of the following is NOT a characteristic of phylum Annelida?
) Ventral nerve cord
) Closed circulatory system

:) Segmentation
l) Pseudocoelom
nswer
nswer: (d) Pseudocoelom

uestion 17.
______ are devoid of respiratory, excretory and circulatory organs.
ı) Threadworms
) Sponges
:) Tapeworms
l) Liver fluke
nswer
nswer: (b) Sponges

uestion 18.
luke infections are diseases of the ________ in humans.
ı) Blood
) Bile
:) Digestive tract
l) Lungs
nswer
nswer: (c) Digestive tract

uestion 19.
/ater-Vascular system is found in
ı) Sea-anemone
) Sea-pen
:) Sea-cucumber
l) Sea-horse
nswer
nswer: (c) Sea-cucumber
uestion 20.
rder Rhynchocephalia consists of
ı) Tuataras
) Lizards and snakes
:) Turtles and tortoises
l) Crocodiles, alligators, caimans
nswer
nswer: (a) Tuataras

olutions For Class 11 Biology Animal Kingdom

olutions for Class 11 Biology Chapter 4 Animal Kingdom:

nimal Kingdom Phylum List

ection Name	Topic Name
	Animal Kingdom
1	Basis of Classification
2	Classification of Animals
3	Summary

TEXTBOOK QUESTIONS SOLVED

.What are the difficulties that you would face in classification of animals, if ommon fundamental features are not taken into account?

oln. The common fundamental features used for classifying animals include body ymmetry, arrangement of cells, nature of coelom, level of organisation. Animal assification would be very confusing if fundamental features are not considered.
)Animals having different levels of organisation would have been placed in same group. g., Sponges and Cnidarians having cellular and tissue level of organisation respectively.
i)Animals showing varied types of germinal layers would have been placed together, as iploblastic cnidarians and triploblastic platyhelminthes.
ii)Animals having different body symmetry would have been placed together, as oelenterates with radial symmetry and platyhelminthes with bilateral symmetry.
v)There would have been no classification of animals based on with or without body avity..
)Placing of oviparous and viviparous animals together.

.If you are given a specimen, what are the steps that you would follow to classify ?

oln. Various steps considered to classify a specimen are:
)Mode of nutrition – It can be autotrophic, holozoic, saprophytic or parasitic.
i)Complexity of body structure – Whether the specimen is unicellular or multicellular.
ii)Presence or absence of membrane bound organelles.
v)Body symmetry, i.e., the plane by which organism can be divided into two equal halves.
)Presence or absence of coelom, it can be acoelomates, pseudocoelomates, eucoelo-ates.
i)Phylogenetic relationship.

.How useful is the study of the nature of body cavity and coelom in the assification of animals ?

oln. Organisms can be classified according to presence or absence of the coelom. The ody cavity, which is lined by mesoderm is called coelom. Animals possessing coelom are alled coelomates, e.g., annelids, molluscs, arthropods, echinoderms, hemichordates and hordates. In some animals, the body cavity is not lined by mesoderm, instead, the esoderm is present as scattered pouches in between the ectoderm and endoderm. Such ody cavity is called pseudocoelom and the animals possessing them are called seudocoelomates, e.g., aschelminthes. In pseudocoelomates, body cavity is derived from astocoel of the embryo. The animals in which the body cavity is absent are called coelomates, e.g., platyhelminthes.

.Distinguish between intracellular and extra-cellular digestion.

oln. Differences between intracellular and extracellular digestion are:

	Intracellular digestion	Extracellular digestion
(i)	It occurs inside the cell.	It occurs outside the cell in the cavity of the alimentary canal.

(ii)	It involves secretion of digestive enzymes by the surrounding cytoplasm into the food vacuoles.	It involves secretion of digestive enzymes by special cells into the cavity of alimentary canal by ducts.
(iii)	Here, the products of digestion diffuse into the cytoplasm.	Here, the products of digestion diffuse across the intestinal wall into different parts of the body.
(iv)	It is less efficient and there is no regional differentiation.	It is more efficient and gut shows regional differentiation.
(v)	It occurs in unicellular organisms and some other lower organisms.	It occurs in multicellular organisms.

.What is the difference between direct and indirect development?

oln. Differences between direct development and indirect development are :

	Direct development	**Indirect development**
(i)	Young ones may resemble the adult.	In this young hatchlings (larvae) do not resemble the adult.
(ii)	Intermediate stages are absent.	Intermediate stages are present.
(iii)	Metamorphosis is absent.	Metamorphosis is seen in indirect development.
	E.g., Hydra, man	*E.g.*, Frog, cockroach

.What are the peculiar features that you find in parasitic platyhelminthes?

oln.Following are the peculiar features of parasitic platyhelminthes:

) The thick tegument (body covering) resistant to the host's digestive enzymes and ant oxins.

i)Adhesive organs like suckers in flukes and the hooks and suckers in tapeworms for a rm grip on or in the host's body.

ii)Loss of locomotory organs.

v)Digestive organs are absent in tapeworms because digested and semidigested food of he host is directly absorbed' through the body surface.

) Reproductive system is best developed in parasitic flatworms.

i)Parasitic flatworms, such as liver fluke and tapeworms perform anaerobic respiration

ii)They possess a considerable osmotic adaptability, as they can successfully live in fferent media.

.What are the reasons that you can think of for the arthropods to constitute the rgest group of the animal kingdom?

oln. Arthropods are most successful animals and constitute the largest group of the nimal kingdom. They have conquered land, sea and air and make up over three fourth of urrently known living and fossil organisms. They range in distribution from deep sea to ountain peaks. Thick, tough, non-living chitinous cuticle forms the exoskeleton which rotects the organism from predators, help to withstand temperature upto 100°C or mor nd prevents water loss. They have ability to reproduce very fast and less time is neede or young ones to hatch from their eggs. Due to metamorphosis, there is less competitio mong larval and adult forms for food. Cockroaches can even survive nuclear radiations a oisoned earth. All these factors made arthropods the largest phylum among animals.

.Water vascular system is the characteristic of which group among the following ?

) Porifera

) Ctenophora

) Echinodermata

) Chordata

oln. (c) Echinodermata

."All vertebrates are chordates but all chordates are not vertebrates". Justify th atement.

oln. Chordates are the animals that possess notochord (a stiff, supporting rod like ructure present on the dorsal side) at some stage of their lives. Phylum Chordata is vided into three Subphyla: Urochordata or tunicata, Cephalochordata and Vertebrata.

ubphyla Urochordata and Cephalochordata are often referred to as protochordates anc re exclusively marine. In urochordata, notochord is present only in tail of larva and isappears in adults, while in cephalochordata, it extends from head to tail region and ersists throughout the life.
he members of Subphylum Vertebrata a possess notochord during the embryonic perioc nd is replaced by a cartilaginous or bony vertebral column in the adult. Thus all ertebrates are chordates but all chordates are not vertebrates.

0.How important is the presence of air bladder in sces?

oln. Bony fishes have a sac-like outgrowth, the swim bladder also called air bladder, tha rises as an outgrowth from the dorsal wall of oesophagus. It is hydrostatic in function. egulates buoyancy and helps them to swim up and down, thus preventing them from nking. In some species air bladder also helps in respiration. It also serves as resonating hamber to produce or receive sound.

1.What are the modifications that are observed birds that help them fly?

oln. Birds have adapted to aerial mode of life through the following modifications:
) Body is streamlined and spindle shaped which minimise resistance to the wind.
i)Body is covered with feathers. It reduces the friction, prevent loss of heat and help aintain constant temperature.
ii)Forelimbs are modified into wings, which help during flight.
v)Flight muscles are greatly developed
) Most of the bones are pneumatic, hollow and filled with air which makes the body ghter and helps in flight.
i)Birds are warm-blooded. They maintain a high body temperature (40° – 46°C). This is ecessary for flight.
ii)Heart is four-chambered and functions efficiently with double circulation.
iii)Air sacs are present which act as reservoir of air and helps in temperature regulatic
x)Urinary bladder is absent (except in Rhea) and only one ovary is present which reduce he weight, which is essential for flight.

2. Could the number of eggs or young ones produced by an oviparous and viviparous other be equal? Why?

oln. No, the number of eggs or young ones produced by an oviparous and viviparous moth espectively cannot be equal. Oviparous mother lays large number of eggs, as the eggs ar id outside the body, so they are not protected from predators and harsh environmenta onditions, and therefore destroyed. However in viviparous mother, eggs are not laid utside, but the embryos develop inside the mother and thus are protected from the utside harsh environment, thus, the number of eggs produced are less. Therefore, the umber of eggs or young ones produced by an oviparous and viviparous mother respective annot be equal.

3.Segmentation in the body is first observed in which of the following?
) Platyhelminthes
) Aschelminthes
) Annelida
) Arthropoda
oln. (c) Annelida

4.Match the following:
) Operculum (i) Ctenophora
) Parapodia (ii)Mollusca
) Scales (iii)Porifera
) Comb plates (iv)Reptilia
) Radula (v) Annelida
) Hair (vi)Cyclostomata and
hondrichthyes
) Choanocytes (vii)Mammalia
) Gill slits (viii Osteichthyes
oln.(a) – (viii), (b) – (v), (c) – (iv), (d) – (i),
) – (ii), (f) – (vii), (g) – (iii), (h) – (vi).

5. Prepare a list of some animals that are found parasitic on human beings.
oln.List of some animals that are found parasitic on human beings :

Parasite	Nature Endoparasites	Organ
Taenia solium (Pork Tapeworm)	Endoparasites	Small intestine
Schistosoma (Blood fluke)	Endoparasites	Hepatic portal system and mesenteric blood vessels.
Ancylostoma duodenale (Hook worm)	Endoparasites	Small intestine
Wuchereria (Filarial worm)	Endoparasites	Lymph nodes and lymphatic vessels.
Enterobius (Pin worm)	Endoparasites	Colon, caecum or vermiform appendix

Morphology of Flowering Plants - NOTES

The angiosperms or flowering plants show a large diversity in external structure called as morphology (Gk. Morphe—form; logos—study). However, they all are characterised by the presence of roots, stems, leaves, flowers and fruits.

1. Flowering Plants

The plant body consists of a main axis, which may be branched or unbranched bearing lateral appendages.
The main axis is divided into two parts
(i) Root system The underground root system develops from the radicle embryo and helps in fixation of the plant as well as absorption of water and minerals.

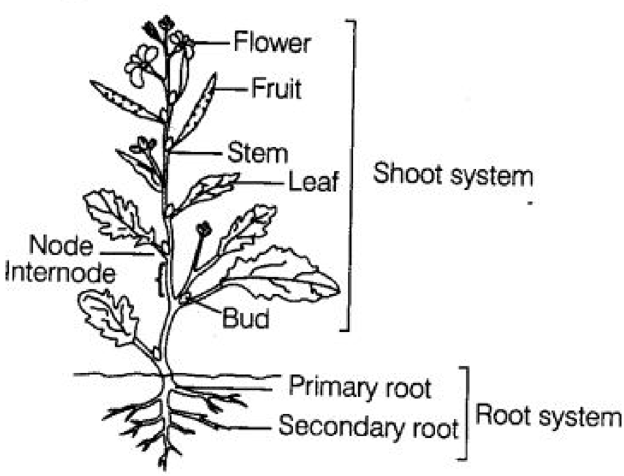


Fig. 5.1 Parts of a flowering plants

(ii) Shoot system The aerial shoot system develops from the plumule embryo. It contains root, stem, leaves as vegetative parts and flowers, fruits and seeds as reproductive parts. The Vegetative parts are involved in various vegetative functions like structural organisation, fixation, absorption, nourishment, growth and maintenance of various components and " reproducting parts are for sexual reproduction and germination of new plants.

The Root

In plants, root is the non-green (due to absence of chlorophyll), cylindrical and descending part that normally grows downwards into the soil. It does not bear leaves, buds and not distinguished into nodes and inter nodes.

Regions of the Root

A typical root contains following five regions. However, there is no clear line of distinction between these regions.

i. Root Cap (Calyptra)

The root is covered at the apex by a thimble or cap-like structure called the root cap. It protects the root meristem from friction of the soil particles and also protect tender apex which allow the passage of root through cells, e.g., Lemna, Eichhornia.

ii. Growing Point (Meristematic) Zone

It is a small (about 1 mm in length) thin-walled region having dense protoplasm. It lies partly within and partly beyond the root cap. Its cell divide regularly and repeatedly for elongation. It is responsible for the growth of the root.

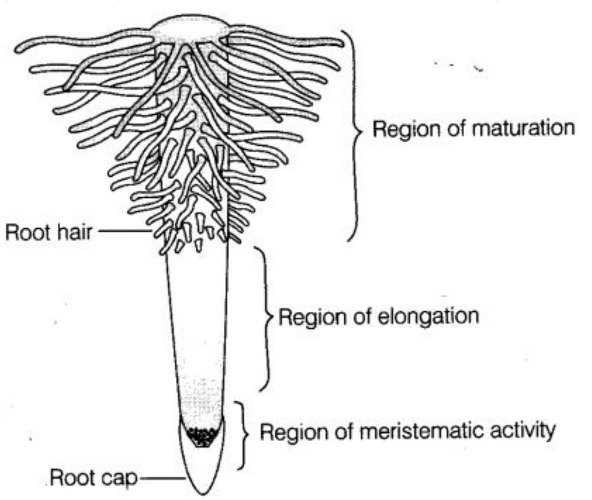


Fig. 5.2 The region of the root tip

iii. Zone of Elongation

It is situated behind the meristematic region (growing point). The cells elongate speedily and increases the length of the root. The cells of this region can absorb water and minerals from the soil.

iv. Root Hair Zone

It is the region where primary tissues differentiate into the root. The vascular tissues like xylem and phloem are formed.

Root hair zone is the most important part of the root for absorption of water (most of the water) from the soil. The root hairs increase the exposed surface of the root for absorption.

v. Zone of Maturation

This zone contains mature cells. It forms the permanent zone of the root and also gives out lateral roots from the interior part of this region, e.g., In dicots and gymnosperms.

- Roots of parasitic plants lack root caps.
- In aquatic plants, root hairs are usually absent.

Types of Root System

The root system can be of two types on the basis of place of origin

i. Tap Root System

The tap root develops from the radicle of embryo of a seed. In most of the plants, primary root persists and becomes stronger to form tap root. The first root forms by the elongation of radicle and is called primary root. It continuously grows and produces lateral roots called secondary roots.

The further branches of the secondary roots are called tertiary roots and so on. These types of roots are present in dicots, e.g., Pea, gram, groundnut, etc.

ii. Adventitious Root System

The roots developing from any part of the plant other than the radicle are known as adventitious roots (L.adventitious .extraordinary). These are usually found in monocots.

The adventitious roots can be further classified as following on the basis of nature of development

(a) Fibrous Roots The primary root soon gets replaced by a cluster of slender, thread-like roots originating from the base of the stem, e.g, Triticum vulgare (wheat), Oryza sativa (rice), Allium sepa (onion).

(b) Foliar Roots These roots develop from the leaf, i.e., from the petiole of the leaf, e.g., Pogostemon, rubber plant.

(c)True Adventitious Roots These roots develop from the nodes and internodes of the stem, e.g., Prop roots of banyan (Ficus), climbing roots of money plant (Pothos), roots from the stem when partially immersed in water (Coleus), roots from nodes (Oxalis repens) etc.

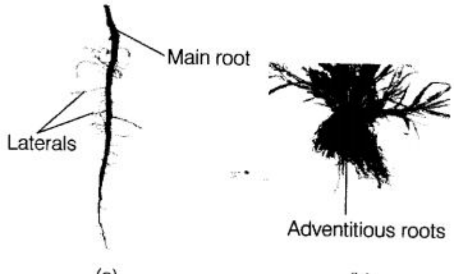


Fig. 5.3 Different types of root system
(a) Tap (b) Adventitious

Modification of Roots

The modifications are the changes in shape, form or structure in an organ to carryout special function other than or in addition to the normal functions. Modification of roots are found in both tap roots ancf adventitious roots.

Modification of Tap Roots

The tap roots are modified for the function like storage, nitrogen-fixation and respiration.
(a) Conical Roots These are fleshy tap roots that resemble a cone (broad at the base and gradually tapering towards the apex), e.g., carrot (Daucus carotd).
(b) Fusiform Roots The primary root is spindle-shaped. It is swollen in the middle and gradually tapers at both the ends, e.g., Radish (Raphanus sativus).
(c) Napiform Roots The primary root is almost spherical (pitcher-shaped) at the base and tapers abruptly at the lower end, e.g., – beetroot (Beta vulgaris),-turnip (Brassica rapa), etc.
(d) Tuberous Roots The primary root becomes thick and fleshy but do not attain any definite shape (irregularly-shaped), e.g., 4 O'clock plant (Mirabilis jalapd), Echinocystis lobata.

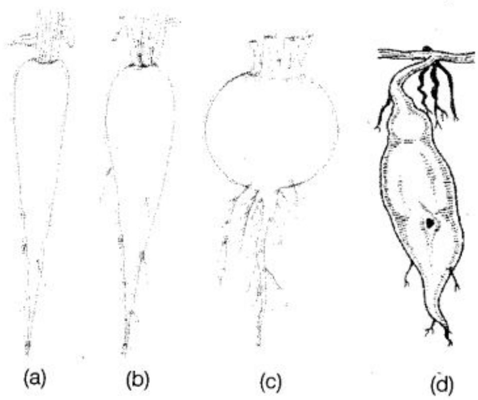


Fig. 5.4 Modification of tap roots for storage
(a) Conical root (carrot) (b) Fusiform root (radish)
(c) Napiform root (turnip) (d) Tuberous root (4 O'clock plant)

(e) Nodulated Tap Roots In this the secondary, tertiary and sometimes primary roots bear many small irregular swellings called root nodules which contain countless, minute nitrogen fixing bacteria of the genus Rhizobium, e.g., groundnut (Arachis bypogea), clover (Medicago falcata), pea (Pisum sativum), etc.

(f) Pneumatophores These are special roots that develop in mangrove plants (grow in marshy areas). The pneumatophores or aerophores or respiratory roots grow vertically upward and are negatively geotropic.
They have minute breathing pores called pneumatophores or lenticels present on the tips of vertical roots that help in getting oxygen for respiration.

Modification of Adventitious Roots
The adventitious roots are modified to perform several additional functions like food storage, mechanical support and other vital functions.
(a) Fasiculated Roots These arises in clusters from the base of the stem, e.g., Dahlia, Asparagus.
(b) Nodulous Roots These roots have swellings occur only near the tips, e.g., Arrow root (Maranta), amia haldi (Curcuma amadd).
(c) Tuberous Roots (Single Root Tubers) These are swollen without any definite shape, e.g., Ipomoea batatas (sweet potato).
(d) Prop (Pillar) Roots The prop roots grow as the horizontal branches of the stem and grow vertically downward.
They become thick pillar-like and provide mechanical support to the giant trees, e.g., Banyan tree (Ficus benghalensis).

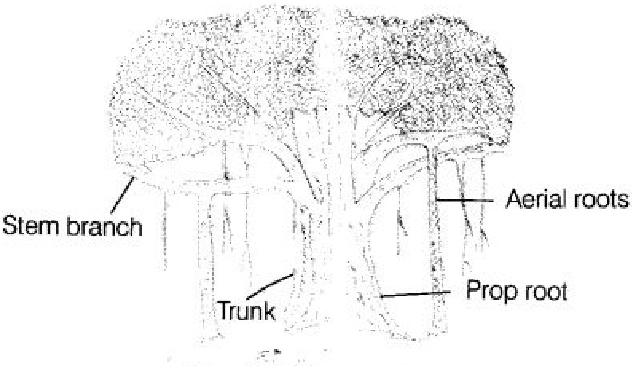


Fig. 5.5 Banyan tree

(e) Stilt Roots These are small thick supporting roots growing obliquely from the basal nodes of the main stem. These provide mechanical support, e.g., Saccharum officinarum (sugarcane), Zea mays (maize).

(f) Climbing (Clinging) Roots These roots are found in climbers. They may arise from the nodes, e.g., Ivy, Pothos (money plant).

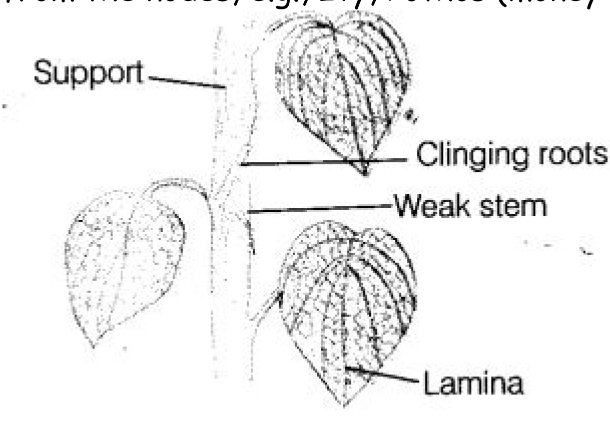


Fig. 5.6 Betel (*Piper betel*)

(g) Assimilatory (Photosynthetic) Roots These roots have chlorophyll and can synthesise food, e.g., Aerial or hanging roots of some orchids.

(h) Parasitic (Sucking) Roots These roots occur in parasitic plant for absorbing nourishment from their host. These roots function as haustoria, e.g., Cuscuta (dodder).

Functions of Roots

The major functions of roots are as follows

(i) Fixation Root provides fixation to the plants with soil.

(ii) Absorption Roots absorb water and minerals from the soil and provide it to all parts of the body.

Storage Roots of many plants store food for the use of other plant parts and for animals.

(iv) Aeration Plants growing in waterlogged soil or marshy areas have special roots,

i.e., pneumatophores for respiration.
(v) Conduction Roots transport water and minerals in upward direction for the uses of stems and leaves.

The Stem

The stem is the ascending part of the axis bearing branches, leaves, flowers and fruits. It develops from the plumule of the embryo of a germinating seed.

It shows distinction into nodes and internodes; where node is the region from where leaves are born and internodes are the region between two nodes. Its apex bears a terminal bud for growth in length.

A bud can be defined as a condensed embryonic shoot that has a growing point surrounded by closely packed immature leaves. When bud grows, the internodes become longer and the leaves spread out, resulting in the formation of a young shoot.

Note:

The largest bud is cabbage.

Bamboo is considered to be tallest herb, tallest shrub or arborescent grass. Bamboos are called culms, after the jointed nature of their stems.

Forms of Stem
Stem may be aerial, subaerial or underground. In most of the plants, stems grow above the soil. These are aerial stems. The aerial stems of some plants trail or creep on the ground. They are called subaerial stems. In some plants, the stem grow in the soil and are called underground stems.

i. Aerial Stems
The aerial stems have two forms, i.e., reduced stem and erect stem.
(a) Reduced Stems It is reduced to a small disc. The * nodes and internodes are not distinguished, e.g., carrot, radish, turnip, etc. In some aquatic plants, the reduced discoid stem is green and flattened to float on the surface of water. It does not bear leaves, e.g., Lemna, Wolffia, Spirodela. In underground structures also a reduced, non-green stem is found, e.g., Garlic, onion and lily.
(b) Erect Stems These stems are strong enough to remain erect or upright without any external support.

ii. Subaerial Stem
In subaerial stems, some part lives underground, whereas, the remaining part of the stem is aerial.
The subaerial stem are also divided into two forms
(a) Upright Weak Stems These stems are weak which climb up a support to expose their foliage and reproductive organs.

These are of two types twiners and climbers
(a) Twiners These are long, slender and very sensitive and coil around an upright support on coming in contact, e.g, Dolichos lab lab (bean), Clitoria (butterfly pea), Cuscuta.
(b) Climbers These have weak and flexible stem which climb up a support with the help of certain clasping or clinging structures, e.g., Bougainvillea.
(c) Prostate Weak Stems These weak stems take support of the ground for spreading as growth occurs.

They are of following four types

Trailers (creepers) They trail along the surface and do not climb up.

Runners These are subaerial weak stems that grow horizontally along the soil surface, e.g., Cynadon (lawn grass), Centella (brahmi booti), Oxalis, etc.

Stolons These subaerial weak stems are horizontal or branched runners with long internodes which can pass over small obstacless. Stolons, also propagate vegetatively like runners, e.g, Fragaria verica (strawberry), Jasminum (jasmine), Mentha piperita (peppermint).

Offsets These weak stems are one internode long, stout, slender and runs horizontally and terminates in a bud at a short distance that develops into adventitious roots, e.g., Pistia (water lettuce), Eichhomia (water hyacinth), etc.

iv. Underground Stems
The stem of some plants lie below the soil surface. They are non-green, store food as means of perennation and vegetative propagation.

They are of following types 885082
(a) Rhizome It is a prostrate thick stem growing horizontally beneath the soil surface. It has distinct nodes and internodes. The. nodes bear small scale leaves with buds in their axils, e.g., Zingiber (ginger officinale), Curcuma domestica (turmeric).

(b) Suckers These are non-green slender stem that grows horizontally in the soil and ultimately comes out to form a new aerial shoot. Each sucker contains one or more nodes with scale leaves and axillary buds, e.g., Mentha (podina), Chrysanthemum (guldaudi).

(c) Corm It is a swollen condensed form of rhizome which grows in the vertical direction in the soil. It stores a large amount of food, e.g., Amorphophallus, Colocasia (taro).

(d) Tuber It is a swollen end of underground stem branches. Each tuber has many notches on the surface called eyes or buds, which grow into new plants, e.g, Solanum tuberosum (potato).

(e) Bulb It is a highly reduced disc like stem. It bears a large number of fibrous adventitious roots at its base. Leaf bases form bulblets. The bulblets grow into new plants, e.g., Allium cepa (onion), Allium sativum (garlic).

Branching Pattern of Stem
The stems may be branched or unbranched.
Branching in stems may be dichotomous and lateral.
(i) The dichotomous branching occurs by the division of the apical growing point or bud into two equal parts in a forked manner. It occurs in lower plants-cryptogams (non-flowering plants), higher plants~Hyphaene (palm), Canscora, screw pine, etc.

(ii) The lateral branching occurs from the axillary buds of the nodes, e.g., Pinus, grapevine, etc.

Functions of Stem
Stems perform various primary and secondary functions.

Primary Functions
(a) It bears leaves, fruits, flowers and seeds in position.
(b) It conducts water and minerals to roots, leaves, flowers, fruits, etc.
(c) It holds flower in suitable position, so that pollination and fertilistaion takes place.

Secondary Functions
(a) Many stems store food as reserve food materials.
(b) Some stems also help in photosynthesis and vegetative propagation.
(c) The underground stems help in perennation.
(d) Stem branches provide support to its various parts.

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Modification of Stem

The various forms of aerial stem modification are following

i. Stem Tendrils

These are thin, long and sensitive structures which can coil around a support. Tendrils can be of following types on the basis of their origin (d) Axillary Arise from axiallary buds, e.g., Passiflora (passion flower).

(b) Extra axillary Develop near the axillary bud, e.g., Lujfa, Cucurbita (pumpkin), etc.

(c) Apical bud These are modified to form tendrils, e.g., Vitis vinifera.

(d) Floral bud These are modified to form tendrils, e.g., Antigonon.

Stem Thorns

The stem thorns are stiff, woody, sharp and pointed. They develop from axillary bud. They protect the plants from browsing animals, e.g., Citrus, Duranta, Bougainvillea, Pomegranate, etc.

Prickles

These are modified stems and act as climbing organs. They protect the plants from grazing animals and also help in climbing in some cases, e.g., Argemone maxicana (prickly poppy), Rosa indica (rose), Bombax (sembal), etc.

Phylloclade

These are green, flattened structures bearing several nodes and internodes. The true leaves are reduced to spines or scales. They show unlimited growth. Some phylloclades also store food and water. The phylloclades are examples of some xerophytic plants, e.g., Opuntia (nagaphani), Casuarina, Euphorbia.
Cladodes (Cladophylls) .

They are green photosynthetic stems generally one inter node long. These develop by the modification of only stem branches of limited growth and are green (photosynthetic). The true leaves of the plant are reduced to scales or spines, e.g., Ruscus, Asparagus.

ii. Bulbils

These are modified vegetative or floral buds arising in the axil of scale or foliage leaves. The bulbil helps in vegetative propagation, e.g., Lilium, Agave, Dioscorea (wild yam), Oxalis, etc.

The Leaf

The leaf is a lateral, generally Battened structure borne on the stem. It develops at the node and bears a bud in its axil. The axillary bud later develops into a branch. Leaves originate from shoot apical meristems and are arranged in an acropetal order. They are the most important vegetative organs for photosynthesis.

Parts of a Leaf

The leaves also consist of two lateral outgrowths called stipules at their bases.
A typical leaf has three main parts.

i. Leaf Base (Hypopodium)

The leaf is attached to the stem by the leaf base. Monocots, the leaf base is said to be sheathing as it expands and partially and wholly surrounds the stem. In dicots, the leaf base bears two lateral outgrowths called stipules.
In some leguminous plants, the leaf base may become swollen which is called the pulvinus. Leaves with stipules are called stipulate and those without them are termed as exstipulate.

ii. Petiole (Mesopodium)

It is the stalk of a leaf. Petiole help hold the leaf blade towards light. Petiole raises the lamina high to the level of stem so as to provide maximum required exposure to light and air.

iii. Lamina (Epipodium)

The lamina or leaf blade is the green, expanded part of the leaf with veins and veinlets. It has a prominent median vein called the midrib. It produces thinner lateral veins which in turn branch to form veinlets.
The lamina is the seat of photosynthesis, gaseous exchange, transpiration and other metabolic activities. The shape, margin, apex, surface and extent of invision of lamina varies in different leaves.

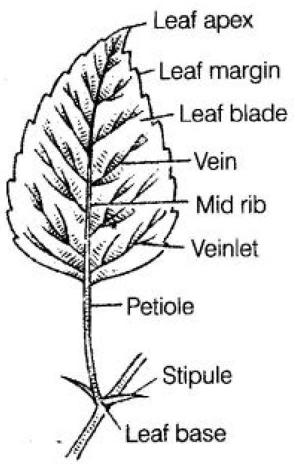


Fig. 5.7 Various parts of a leaf

Venation

The arrangement of veins and veinlets in the lamina of leaf is called venation. The midrib, veins and veinlets are contain vascular tissues, i.e., The xylem and phloem for conduction water, mineral salts and food.

Leaves have mainly two types of venation

i. Reticulate Venation

When the veinlets form a network, the venation is called reticulate. It is found in dicot leaves. However, some monocot leaves like Smilax, Dioscorea and Alocasia also show reticulate venation.

ii. Parallel Venation

When the veins run parallel to each other within a lamina, the venation is termed as parallel, e.g. Calophyllum, Zingiber officinale, etc.

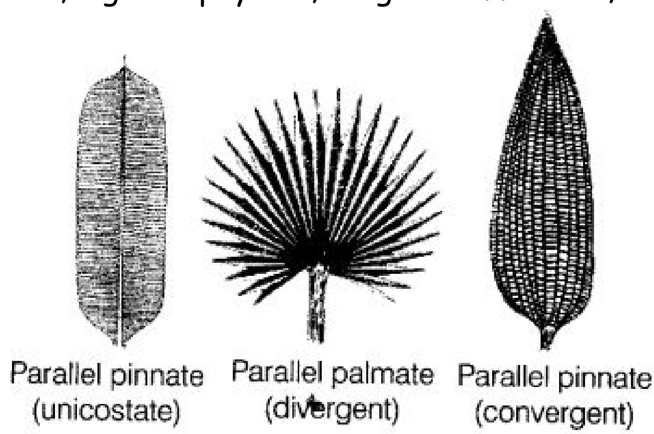


Fig. 5.8 Types of parallel venation

Types of Leaves

Leaves can be of following types

i. Simple Leaves

A leaf having a single or undivided lamina is called simple leaf. The lamina of a simple leaf may be incised but the incisions do not touch the midrib.

The lamina can have various types of incisions which may reach upto half (fid), more than half (partite) or near the base or midrib (sect).

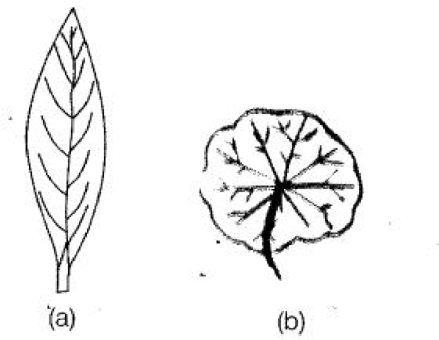


Fig. 5.9 Types of simple leaves
(a) Entire pinnate leaf of mango
(b) Entire partite leaf of garden nastůrtium

Compound Leaves

A leaf is called compound when the incision of the leaf blade goes down to the midrib (rachis) or to the petiole so that the leaf is broken up into a number of segments called leaflets.

A bud is present in the axil of petiole in both simple and compound leaves but not in the axil of leaflets of the compound leaf.

A compound leaf can be of following two types

(a) Pinnately Compound Leaves In these leaves, the incision of lamina is directed towards the midrib, which is known as rachis. Leaflets are arranged on both side on the rachis, e.g., Neem, rose, etc.

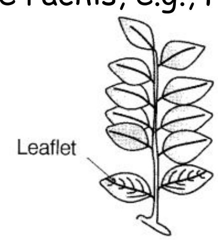


Fig. 5.10 Pinnately compound leaf

(b) Palmate Compound Leaves The leaflets are attached at a common point, i.e., at the tip of petiole as in silk cotton.

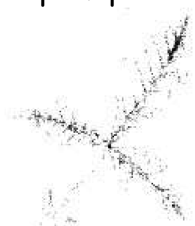


Fig. 5.11 Trifoliate

Phyllotaxy

The pattern of arrangement of leaves on the stem or branch is called phyllotaxy. It helps to avoid overcrowding and provide every leaf with optimum sunshine.

Phyllotaxy is usually of three types

i. Alternate (Spiral) Phyllotaxy

A single leaf arises at each node in alternate manner, e.g, China rose, mustard and sunflower plants.

ii. Opposite Phyllotaxy

A pair of leaves axises at each node and opposite to each other, e.g., Calotropis and Psidium guajava (guava plants).

Whorled (Verticillate) Phyllotaxy

If more than two leaves arise at a node and form a whorl, it is called whorled. The leaves of one whorl generally alternate with those of the adjacent whorls in order to provide maximum exposure, e.g., Nerium (kaner), Alstonia.

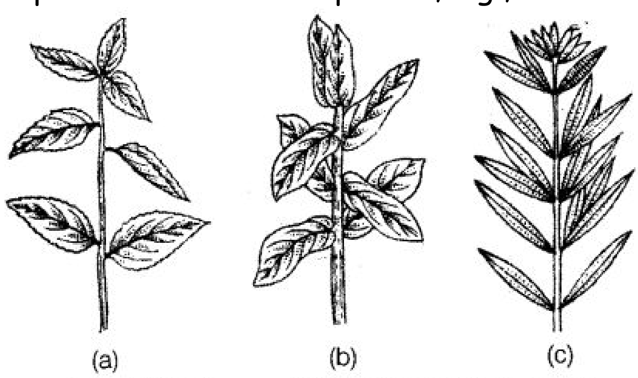


Fig. 5.12 Types of Phyllotaxy (a) Alternate (b) Opposite (c) Whorled

Modification of Leaves

Leaves of plants are modified to perform different additional functions in addition to their main function, i.e., photosynthesis.

i. Leaf Tendrils

These are thread-like sensitive structures, which can coil around a support to help the plant in climbing, e.g, Wild pea (Lathyrus aphaca), Pisum sativum (sweet pea) and Gloriosa superba (glory lily). "

ii. Phyllode

It is a green, short lived and flattened petiole or rachis of a leaf, which performs the function of photosynthesis, e.g, Australian Acacia. Phyilodes develop usually vertically and possess fewer stomata hence, reduce transpiration.

iii. Bladder

The segments of the leaf modify into bladder-like structures, which trap small insects present in the water. e.g., Bladderwort (Utricularia).

iv. Pitcher

It is a petiole modified into a tendril to hold the pitcher upright. The leaf base is expanded to carry out photosynthesis. The leaf apex is modified into a lid, e.g, Nepenthes, Dischidia and Sarracenia.

v. Leaf Spines

The entire leaf or a part of a leaf may be modified into a pointed structure called a spine, as in Opuntia.

vi. Scale Leaves

These are thin, membranous leaves found at the nodal region. Each scale leaf contains an axillary bud in its axil, e.g, Zingiber officinale (ginger).

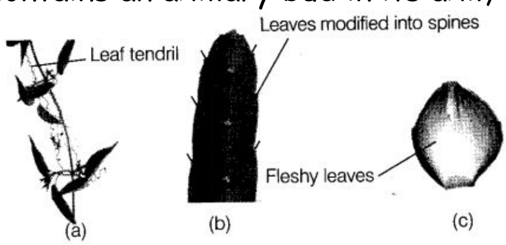


Fig. 5.13 Modification of leaf for (a) Support : tendril (b) Protection : spines (c) Storage : fleshy leaves

Functions of Leaves

The leaves have many primary and secondary functions.

Primary Functions

(a) The most important function of leaves is photosynthesis with the help of sunlight and carbon dioxide.

(b) Leaves contain stomata through, which gaseous exchange occurs,

(c) Leaves are the site of transpiration.
(d) They protect axillary and terminal bud from mechanical injury and desiccation.

Secondary Functions
(a) Leaves store food as in the leaf base, e.g., Onion.
(b) Leaves change into phyilodes to protect against transpiration.
(c) Storage of water in the cells of some succulent plants, e.g., Aloe.
(d) In Salvinia, one leaf of each node is changed into roots that act as balancer for floating.
(e) In some leaves like of Euphorbia, the young leaves are brightly coloured to attract insects for pollination.

The Inflorescence

The arrangement and distribution of flowers over a plant is called inflorescence.
The inflorescence can be of following three types
1. Racemose Inflorescence
In racemose type of inflorescence, the main axis continues to grow and the flowers are borne laterally in an acropetal succession (the older flowers are found towards the base and younger ones at the apex) or centripetal (older towards periphery and younger towards centre).

Fig. 5.14 Racemose inflorescence

2. Cymose Inflorescence
In cymose inflorescence, the tip of the main axis terminates in a flower and further growth continues by one or more lateral branches, which also behave like the main axis.

The arrangement of flowers in either basipetal (younger flowers occupy basal position, while older flowers towards the apex) or centrifugal (older towards center and younger towards periphery).

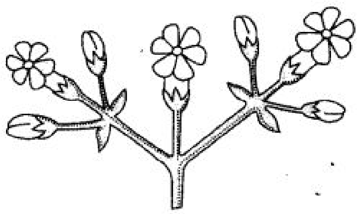


Fig. 5.15 Cymose inflorescence

3. Special Inflorescence

It mainly involves highly modified and densely crowded inflorescences.

The special type of inflorescence can be divided into following types

i. Cyathium

It is highly reduced and is a cup-shaped involucre of five bracts having nectariferous glands. A single large female flower is present in the centre of the cup and scorpioid male flowers surrounded this female flower. Every male flower is represented by a single stalked stamen borne in the axil of a scaly bract, e.g, Euphorbia.

ii. Verticillaster

These are two clusters each having 3-9 flowers that develop on a node in the axils of opposite leaves, e.g., Ocimum sanctum (basil).

iii. Hypanthodium

In this type, the main axis is condensed into a cup or flask-shaped, fleshy receptacle. It bears three kinds of flowers, i.e., male flowers (towards the pore), female flowers (towards the base) and neutral flowers occurs in between male and female flowers, e.g., Peepal (Ficus relegiosa) and banyan (Ficus benghalensis).

The Flower

The flower is the reproductive unit in the angiosperms. It is meant for sexual reproduction. Morphologically, it is considered as a shoot bearing nodes and modified floral leaves. A flowers is called modified shoot because the position of the buds of both flower and shoot which is same and can be in terminal or axillary in position.

Structure of Flower

A flower arises in the axil of a leaf like structure called bract. Flowers with bracts are called bracteate and those without bracts are called ebracteate.

The terminal part of the axis of the flower is the receptacle or thalamus. The receptacle contains sepals, petals, stamens and carpels. If the leaves are present on the pedical, they are called bracteoles.

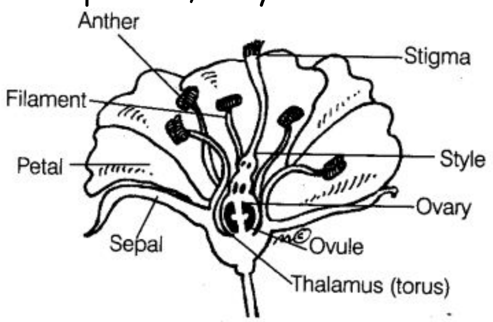


Fig. 5.16 Structure of a typical flower

Parts of a Flower

A typical flower consists of four distinct parts the calyx, the corolla, the androecium and the gynoecium. The calyx and corolla are accessory parts and the androecium and gynoecium are essential parts.

These essential parts consist of two kinds of (male) sporophylls, the microsporophyll (male) and the megasporophyll (female).

A flower can be unisexual or bisexual. It is borne on short or long axis. The axis contains two regions the pedicel and the thalamus or receptacle.

The pedicel may be short, long or even absent. The thalamus is the swollen end of the axis on which the floral whorls are arranged.

Different parts of flower are given below

i. Calyx

It is the outermost whorl of a flower. It is made up of units like sepals. The sepals are generally green, leaf like and protect the flower in the bud stage, i.e., when floral in bud condition. They have veins and stomata like ordinary leaves but are thicker in nature. The sepals may be gamosepalous (sepals united), e.g., Caesalpinia or polysepalous (sepals free), e.g., Crotalaria. The sepals also prevent transpiration from inner parts of the flower. Coloured sepals attract insects for pollination.

ii. Corolla

It is composed of petals. Petals are usually brightly coloured to attract insects for pollination. Like calyx, corolla may also be gamopetalons (petals united) or polypetalous (petals free). The shape and colour of corolla may vary greatly in shape. Corolla may be tubular, bell-shaped, funnel-shaped.

Aestivation

The mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl is known as aestivation. The aestivation pattern is important in classification of – plants.

It is of following types

(a) Valvate Petals come to each other but do not overlap, e.g., mustard (Brassica).
(b) Twisted Regular overlapping of petals occurs in which margin of one petal overlap with the next one petal, e.g., China rose (Hibiscus rosa sinensis).
(c) Imbricate There are five petals, arranged in such a way that one petal is completely external and another petal is completely internal, while three petals are partially external and partially internal, e.g., Cassia, Cullistemon,Caesalpinia.
(d) Vexillary When the largest petal overlaps the two lateral petals which in turn overlap the two smallest anterior petals (keel), the aestivation is called as vexillary or papilionaceous.

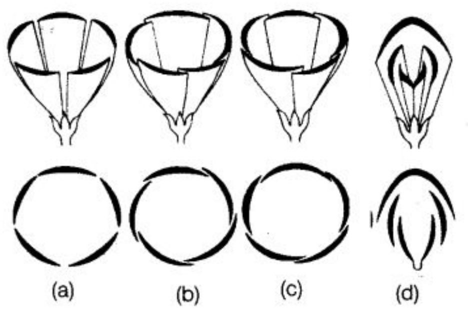


Fig. 5.17 Different types of aestivation of calyx and corolla (a) Valvate (b) Twisted (c) Imbricate (d) Vexillary

iii. Androecium

It is the third whorl of flower composed of stamens or microsporangium. Each stamen, which represents the male reprodutive organ consists of a stalk or a filament and an anther. Each anther is usually bilobed which are attached at the back by a sterile band called connective and each lobe has two chambers, the pollen sacs. The pollen grains are produced in pollen sacs. A sterile stamen is called staminode. Stamens can be of different types depending on their union with other members such as petals or among themselves.

(a) When stamens are attached to the petals, they are epipetalous, e.g., Brinjal.
(b) When stamens are attached to the perianth, the condition is called epiphyllous, e.g., Lily.
(c) The stamens in a flower may either remain free, i.e., polyandrous or may be united in varying degrees.
(d) The stamens may be united into one bunch or one bundle, i.e., monoadelphous as in China rose. It may be two bundles, i.e., diadelphous as in pea or into more than

two bundles, i.e., polyadelphous as in citrus.
(e) There may be variation in the length of filament as in Salvia and mustard.

iv. Gynoecium
Gynoecium is the female reproductive part of the flower and is made up of one or more carpels or megasporangium. Megaspores are produced within the megasporangium.'A carpel consists of three parts, i.e., stigma, style and ovary. The stigma is usually at the tip of style and is the receptive surface for pollen grains.

Ovary is the enlarged basal part on which lies the elongated tube, the style. The style connects the ovary to the stigma. Each ovary bears one or more ovules attached to a flattened, cushion like placenta.

Depending on the number of carpel present may be free or united, gynoecium can be of following types
(a) Apocarpous When more than one carpel is present, they may be free are called apocarpous, e.g., Lotus and rose.

(b) Syncarpous When carpels are fused together, the gynoecium is called syncarpous, e.g., Brinjal and Hibiscus.
The cavity enclosed by the ovary wall is called locule. The number of locules in the ovary correspond to the number of carpels in the gynoecium, i.e., unilocular (only one locule, e.g., Pea), bilocular (two locules, e.g., Tomato), trilocular (three locules, e.g., Ricinus), multilocular (many locules, e.g., Orange and lemon).
The arrangement of ovules within the ovary is known as placentation. The placenta is a tissue, which develops along the inner wall of the ovary. The ovule or ovules remain attached to the placenta.

The placentation can be of different types
(a) Marginal The placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows is called marginal placentation, e.g., Pea.

(b) Axile When the placenta is axial and the ovules are attached to it in a multilocular ovary, the placentation is called axile, e.g., China rose, tomato and lemon.

(c) Parietal When the ovules develop on the inner wall of the ovary or on peripheral part, it is called parietal placentation. Ovary is one chambered but it becomes two-chambered due to formation of the false septum, e.g., Mustard and Argemone.

(d) Free central When the ovules are borne on central axis and septa are absent, the placentation is called free central, e.g., Dianthus and primrose.

(e) Basal In this type, the placenta develops at the base of ovary and a single ovule is attached to it as in sunflower, marigold. The placenta develops directly on the thalamus.

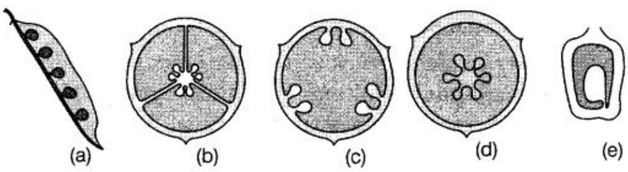


Fig. 5.18 Types of placentation (a) Marginal (b) Axile (c) Parietal (d) Free central (e) Basal

Insertion of Floral Parts (Forms of Thalamus)

The positions of different whorls of flowers are different. This is due to the position of ovary.

These positions may be of three types

i. Hypogynous Flower

The thalamus is conical, dome-shaped or flat. The ovary is present at the top of thalamus. The stamem, petals and sepals are separate and successively inserted below the ovary. Ovary is superior, whereas rest of the structures are inferior, e.g., Brassica, Hibiscus, Petunia.

ii. Perigynous Flower

The margin of thalamus grows upwards forming a cup like structure called calyx tube. The calyx tube encloses ovary, but remains free from it and the sepals, petals and stamens are present in it. The ovary is half inferior, e.g., rose, plum, peach, etc.

iii. Epigynous Flower

The thalamus grows upwards to completely develop the ovary and also fused inseparably with the latter. The other floral parts are borne at the top of the fused thalamus and ovary. The ovary is called inferior, e.g., Helianthus (sunflower), Cucurbita (pumpkin), Pyrus (apple).

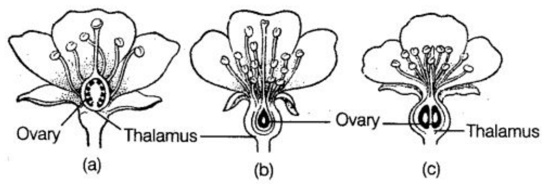


Fig. 5.19 Arrangement of floral leaves on thalamus

Number of Floral Parts

When the floral appendages are in the multiple of 3, 4 or 5, the flower is considered as trimerous, tetramerous or pentamerous respectively. Dicotyledonous flowers are usually di, tetra or pentamerous, while, monocotyledonous flowers are trimerous.

Symmetry of A Flower

The symmetry of a flower depends upon the shape, size and arrangement of floral parts, e.g., Calyx, corolla, androecium and gynoecium. Flowers can be actomorphic and zygomorphic on the basis of symmetry.

Actinomorphic

In this type, a flower can be divided into exactly equal halves by any vertical section passing through the centre of a flower, e.g., Mustard, datura.

Zygomorphic

In this type, flower can be divided into two identical halves through only one particular vertical plane, e.g., Ocimum, Cassia.

The Fruit

The characteristic feature of flowering plants is fruit. Fruit is a mature or ripened ovary, developed after fertilisation.
During fertilisation, the important changes taking place in the ovary are
(ii) The ovules present in it develops into seeds.
(ii) The wall of the ovary thickens and ripens into pericarp (fruit wall).

Note:

Fruits developed from the fertilised ovary is called true fruits. A true fruit has two parts pericarp and the seeds.

Fruits developed from any part of the flower along with ovary is called false fruits. The thalamus grows along with the ovary to form a false fruit i.e. in Pyrus malus (apple).

The fruit of mango and coconut are also known as drupe, as it develop from monocarpellary superior ovaries and have only one seed.

The ovary after these changes is known as the fruit. If a fruit is formed without fertilisation, it is called parthenocarpic fruit, e.g., Banana, grapes, pineapple, etc. The parthenocarpic fruits do not have seeds.

The fruit consists of wall or pericarp and seeds. The pericarp may be dry or fleshy. When pericarp is thick and fleshy, it is differentiated into outer epicarp, the middle mesocarp and the inner endocarp.

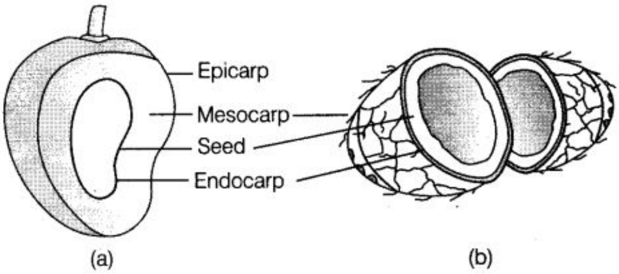


Fig. 5.20 Parts of a fruit (a) Mango (b) Coconut

Types of Fruits

Fruits can be broadly classified into following three types

i. Simple Fruits

A simple fruit develops from the single simple or compound ovary of a flower. These can be dry fruits (pericarp dry) or succulent fruits (pericarp fleshy).

ii. Aggregate (Etaerio) Fruits

An aggregate fruit is a group of fruitlets which develops from a flower having polycarpellary apocarpous (free) gynoecium. The aggregate fruit is also called etaerio.

iii. Multiple (Composite) Fruits

A composite (multiple) fruit develops from an entire inflorescence. The multiple fruit is composed of a number of closely associated fruits (which may or may not get fused) along with its peduncle. Hence, these fruits are pseudocarps and are also called inflorescence fruits. Pomology is the branch of horticulture that deals with the study of fruits and their cultivation.

Edible Parts of Some Common Fruits

Simple Fruits	Scientific Name	Type	Edible Parts
Wheat	*Triticum aestivum*	Caryopsis	Endosperm and embryo
Maize	*Zea mays*	Caryopsis	Endosperm and embryo
Rice	*Oryza sativa*	Caryopsis	Endosperm and embryo
Tomato	*Lycopersicum esculentum*	Berry	Pericarp and placenta
Litchi	*Litchi (Nephalium) chinensis*	Nut	Fleshy aril
Banana	*Musa paradisiaca*	Berry	Mesocarp and endocarp
Brinjal	*Solanum melongena*	Berry	Pericarp and placenta
Coconut	*Cocos nucifera*	Drupe	Endosperm, testa, cotyledon and embryo
Almond	*Prunus amygdalus*	Drupe	Seeds
Cucumber	*Cucumis melo*	Pepo	Mesocarp and endocarp
Aggregate Fruits			
Strawberry	*Fragaria vesco*	Etaerio of achenes	Fleshy thalamus and seeds
Lotus	*Nelumbo nucifera*	Etaerio of achenes	Fleshy thalamus and seeds
Multiple Fruits			
Jack fruit	*Artocarpus heterophyllus*	Sorosis	Fleshy axis, bracts, perianth and seeds
Fig	*Ficus carica*	Syconus	Peduncle and seeds
Mulberry	*Morus alba*	Sorosis	Fleshy axis and succulent perianth

Importance of Fruits

(i) Fruits are a source of vitamins, organic acids, minerals, pectin and sugars and some of them are used as vegetables, e.g., Okra (lady's finger), tomato, pumpkin, cucumber, gourd, etc.

(ii) Cereals are one seeded dry fruits, form the stable food of humans.

(iii) Fruits are important foods for fruit eating birds (frugivorous) and some animals.

(iv) Some fruits are also used as medicines, e.g., Emblica officinalis (amla), Datum stramonium (datura), Papaver somniferum (poppy), etc.

(v) They protect immature seeds against climatic conditions till their maturity.

(vi) The unripe fruits are bitter due to the presence of tannins, bitter alkaloids, astringents, sour acids, etc. This way they keep the animals away from eating them.

The Seed

Seed is a ripened ovule which contains an embryo or tiny plant with sufficient reserve food for the development of embyo. The ovules after fertilisation develops into seeds. A seed is made up of seed coats and an embryo. The embryo is made up of a radicle, an embryonal axis and one (wheat and maize) or two cotyledons (gram and pea).

Types of Seeds

Seeds can be classified into two different types based on the number of cotyledons and presence or absence of endosperms, i.e., dicotyledonous and monocotyledonous seed.

i. Dicotyledonous Seed

Gram seed is a dicot seed formed in a small pod or legume. The outermost covering is the seed coat. An endosperm is absent. Seed can be studied under two heads, i.e., external structure and internal structure.

It is light or dark brown in colour. Its surface may be smooth or wrinkled. A small oval scar present at the side called hilum. It is the point where the stalk or funicle of the seed is attached to it. A narrow ridge called raphae runs from hilum to chalaza inside the furrow. A small pore called micropyle present between the hilum and pointed end.

The outermost covering of the seed is seed coat. The outer hard and leathery layer of the coat is called testa and the inner thin and membranous layer is the tegmen. In some seeds, the tegmen and testa are fused.

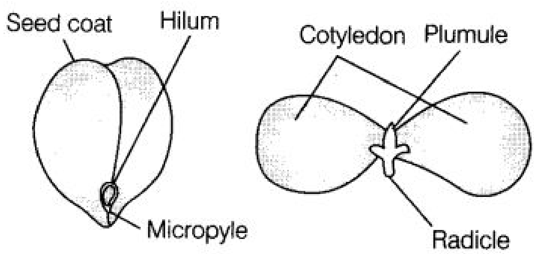


Fig. 5.21 Structure of dicotyledonons seed

The seed coat encloses the embryo, which is differentiated into a radicle, a plumule and cotyledons. The radicle develops into root and plumule into shoot. Cotyledons may be one or two to serve as reserve food.

Hypocotyl is a part present between the point of attachment of cotyledon and radicle. Epicotyle is present between point of attachment of cotyledons and plumule.

In some seeds, such as castor seeds, the endosperm is formed as a result of double fertilisation, which is a food storing tissue. In plants like bean, gram and pea, the endosperm is not present in mature seeds (i.e., non-endospermous seeds).

ii. Monocotyledonous Seed

The monocotyledonous seeds are endospermic but some as in orchids are non-endospermic. In the cereals, such as maize, the seed coat is membranous and generally fused with the fruit wall.

Structure of Monocotyledonous Seed

The endosperm is bulky and stores food. The outer covering of endosperm separates the embryo by a proteinous layer called aleurone layer. The embryo is small and situated in a groove at one end of the endosperm. It consists of one large shield-shaped cotyledon known as scutellum and a short axis with a plumule and a radicle. The plumule and radicle are enclosed in sheaths which are called coleoptile and coleorhiza respectively.

Coleoptile has a terminal pore for the emergence of first leaf during germination. The sheath is capable of growth. It helps the future shoot in passing through the soil during germination, e.g., Maize grain is whitish, yellow, violet or red in colour. It has smooth or shiny surface.

Its grain is covered with a single, thin hard covering. It is formed by the fusion of seed coat or testa and the fruit wall gr pericarp.

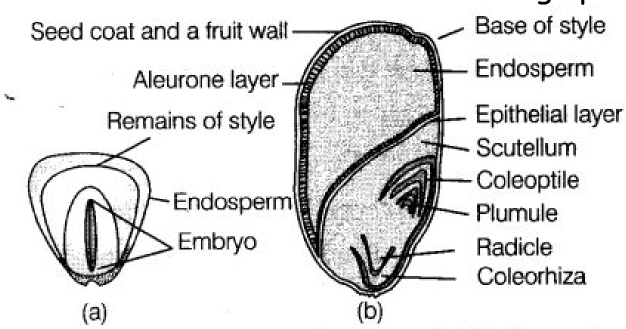


Fig. 5.22 Structure of maize grain (a) External structure

Semi-Technical Description of a Typical Flowering Plant

The description of a flowering plant should be brief, sequential and in scientific language. This is required to designate a plant in its appropriate taxonomic position. The Plant can be Described Briefly in the following Way

Habit	Herb, shrub, trees, climber, creeper, etc.
Habitat	Mesophyte, xerophyte or hydrophyte, etc.
Vegetative Character	
Roots	Tap or adventitious root system.
Stem	Herbaceous or woody, smooth, hairy, spiny, prickly, cylindrical, angular or flattened, etc.
Leaves	Deciduous or persistent, phyllotaxy may be alternate, opposite or whorled, petiolate or sessile, reticulate or parallel, blade may be simple or compound.
Floral Characters	
Inflorescence	Cymose or racemose and their subtypes.
Flower Parts	Sessile or pedicellate, bracteate or ebracteate, unisexual or bisexual, zygomorphic or actinomorphic, hypogynous, perigynous or epigynous, complete or incomplete, isomerous or heteromerous, etc.
Calyx	Polysepalous or gamosepalous, deciduous or persistent.
Corolla	Polypetalous (free) or gamopetalous (united), aestivation and special appendages.
Androecium	Polyandrous or united. If united, adelphous, syngenesious or synandrous.
Gynoecium	Free or united carpels, ovary superior or inferior, etc.
Fruits	Simple, aggregate or multiple, true or false fruits.
Seeds	Monocot or dicot, endospermic or non-endospermic, etc.

Floral Formula

The symbolic representation of floral characters of a flower is called floral formula. For example, the floral formula ofBrassica (mustard) represented as given by

$$\text{Ebr} \oplus ⚥ K_{2+2} C_4 \ A_{2+4} \ G_{(2)}$$

Description of this formula is Ebracteate, actinomorphic, bisexual, bimerous, calyx-4, polysepalous, in two whorls of two each corolla-4, polypetalous, cruciform, androecium-6, polyandrous, tetradynamous in two whorls, one with two, gynoecium—bicarpellary syncarpous, superior.

Symbols used in Floral Formula

Br – Bracteate	G – Gynoecium and carpels
Brl – Bracteolate	$\overline{G}$ – Inferior ovary $\underline{G}$ – Superior ovary
⊕ – Actinomorphic	Ebr – Ebracteate
⚥ – Hermaphrodite or bisexual	Ebrl – Ebractealate
♀ – Female or pistillate	% – Zygomorphic
♂ – Male or staminate	
Epi – Epicalyx	
C – Corolla and petals	N – Nectar
K – Calyx sepals	
P – Perianth and tepals	
A – Androecium and stamens	Std – Staminodes

Symbols for Number of Floral Parts

The number of floral parts are written at right foot of the symbol. If they are fused they are bracketed.

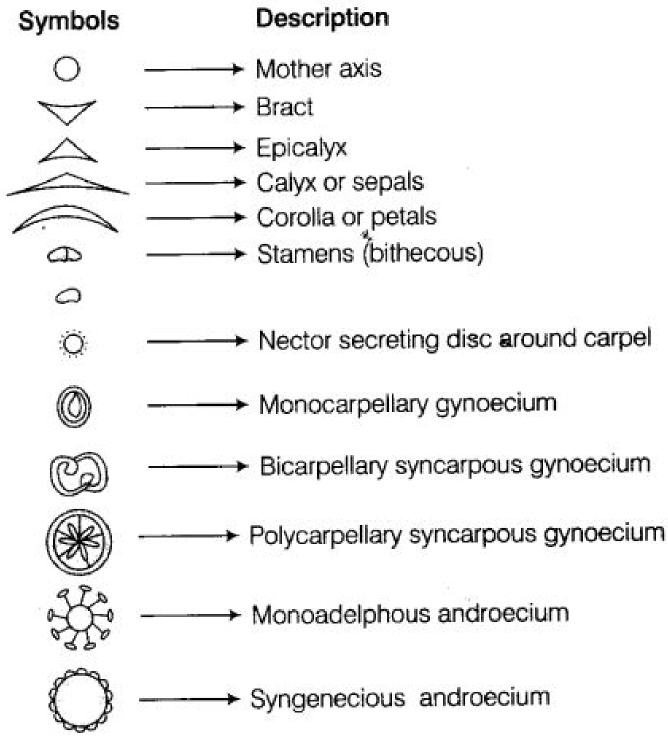
Some examples are given below

Sepals 6 free	K_6
Sepals 6 fused	$K_{(6)}$
Petals 5 free	C_5
Petals 5 fused	$C_{(5)}$
Stamens 10 free	A_{10}
Stamens 10 in two whorls of 5 each	A_{5+5}
Stamens indefinite	A_{∞}
Stamens 10, diadelphous (9 fused and 1 free)	$A_{(9)+1}$
Carpels two free	G_2
Bicarpellary syncarpous	$G_{(2)}$
Epipetalous	$\overset{\frown}{CA}$

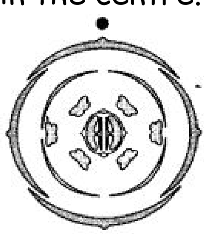
Floral Diagram

A floral diagram provides information about the number of parts of a flower, their arrangement and the relation, they have with one another.

The floral diagram of flower tell us about the following



In the floral diagram, the position of the mother axis with respect to the flower is represented by a dot on the top of the floral diagram.. Calyx, corolla, androecium and gynoecium are drawn in successive whorls, calyx being the outermost and the gynoecium in the centre.



$\oplus$ ⚥ $K_{2+2}\ C_4 A_{2+4}\ \underline{G}_{(2)}$

Fig. 5.23 Floral diagram with floral formula

Description of Some important Families

I. Family-Fabaceae

This family was earlier called Papilionoideae, a sub-family of family—Leguminosae. It is distributed all over the world.

Morphology of Flowering Plants 0777 023 444

1. system position

Division	–	Embryophyta
Sub-division	–	Angiospermae
Class	–	Dicotyledonae
Sub-class	–	Polypetalae
Series	–	Calyciflorae
Order	–	Rosales
Family	–	Fabaceae

2. Distribution The family includes 600 genera and 13000 species. It is distributed all over the world except the Arctic regions.

3. Habit The plants are mosdy herbs, however shrubs, trees and climbers are also common.

4 Vegetative Characters

(i) Root Tap root with lateral branches. The lateral branches mostly contain bacterial nodules (with Rhizobium bacteria which fix atmospheric nitrogen).
(ii) Stem Herbaceous or woody, branched, erect or climbing.
(iii) Leaf Alternate, pinnately compound or simple, leaf base, pulvinate, stipulate, venation-reticulate.

5. Floral Characters

(i) Inflorescence Simple raceme, axillary cyme or solitary.

(ii) Flower Bracteate, pedicellate, subsessile, bisexual, mostly, irregular, zygomorphic, sometimes regular, pentamerous, hypogynous or slightly perigynous.
(a) Calyx Sepals 5, gamosepalous, imbricate aestivation.
(b) Corolla Petal 5, polypetalous, papilionac¬eous, consisting of a posterior standard, two later wings, two anterior ones forming a well (enclosing stamens and pistil), vexillary aestivation.
(c) Androecium Stamens 10, usually diadelphous [(9) +1] or monadelphous, sometimes free, polyandrous, another dithecous, basifixed (attached by its base).
(d) Gynoecium Monocarpallary, ovary superior, unilocular with marginal placentation, style bent, stigma simple and hairy.
(e) Fruit Legume (pod).
(f) Seed One to many non-endospermic.

(iii) Floral Formula

$Br\ \%\ ⚥\ K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1}\ \underline{G}_1$

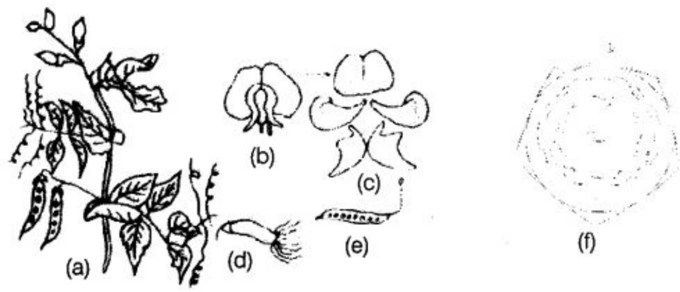


Fig. 5.24 *Pisum sativum* (pea) plant (a) Flowering twig (b) Flower (c) Petals (d) Reproductive parts (e) LS of carpel (f) Floral diagram

Economic Importance with Examples

Plants belonging to this family hqs their importance in the following fields
(i) Pulses and Vegetables The family is an important source of pulses and vegetables. The ^pulses are rich in proteins like gram (chana), pea (matar), field bean (bankla), cluster bean (gwar), lima bean (lobia), lentil (masoor), bean (sem), soya(soyabean), etc.

(ii) Oil Edible oils are obtained from the seeds of Arachis hypogaea (groundnut) and Glycine max (soyabean). Vegetable ghee is prepared by using the oils after hydrogenation.

(iii) Timber Dalbergia sissoo (Indian redwood),Dalbergia latifolia (Indian rose wood), are important timber yielding trees of the family.

(iv) Dye Indigofera tinctoria (indigo), Butea monosperma (flame of the forest) is used to produced red dye used as an astringent.

(v) Fodder Plants like Trifolium alexandrium (barseem), Medicago sativa, Cyamopsis tetragonoloba, etc., yield fodder for the cattle.

(vi) Fibres Crotalaria juncea (sunhemp) is used to produce fibres.
(vii) Ornamentals Some common ornamental plants are Lathyrus odoratus (sweet pea), Clitoria (butterfly pea), Lupinus, etc., are common ornamental plants.

(viii) Jewellar s Weights The seeds of Abrus precatorius (ratti) are used weight by jewellars.

(ix) Medicinal Plants The flowers of Trifolium pratense are used in whooping cough. The gum of Butea monosperma (dhak) is useful for treating dysentery and diarrhoea. There are several other examples in this family that are used as medicines.

II. Family-Solanaceae

It is a large family, commonly called as the 'potato family, it is widely distributed in tropics, sub-tropics and even temperate zones.

1. Systematic Position

Division	–	Spermatophyta
Sub-division	–	Angiospermae
Class	–	Monocotyledonae
Order	–	Liliflorae
Series	–	Coronarieae
Family	–	Liliaceae

2. Distribution

The family is represented by 90 genera and 2800 species distributed in both tropical and temperate regions.

3. Habit

Annual or perennial herbs, shrubs or rarely soft wooded trees.

4. Vegetative Characters

(i) Root Usually tap roots.

(ii) Stem Herbaceous or woody, hair or prickles often present, sometimes underground tubers (Solanum tuberosum).

(iii) Leaf In vegetative parts alternate and floral regions opposite, exstipulate, simple, rarely pinnately compound as in potato and tomato.

5. Floral Characters

(i) Inflorescence Solitary, axillary or cymose as in Solarium.

(ii) Flower Bisexual, actinomorphic, ebracteate, pedicellate, pentamerous and hypogynous.

(a) Calyx Sepals 5, united, valvate aestivation, usually persistent as in brinjal, tomato, chilly, etc.

(b) Corolla Petals 5, united, valvate aestivation, rotate or tubular, rarely funnel-shaped.

(c) Androecium Stamens 5, epipetalous, alternating with, petals, inserted in corolla tube, filaments usually of unequal length, anthers bithecous.

(d) Gynoecium Bicarpellary, syncarpous, ovary superior, bilocular, placenta swollen with many ovules.

(e) Fruits Berry or capsule.

(f) Seeds Endospermic, embryo straight.

(iii) Ebr $\oplus$ $K_{(5)}$ $\overbrace{C_{(5)}\ A_{(5)}}$ $\underline{G}(2)$

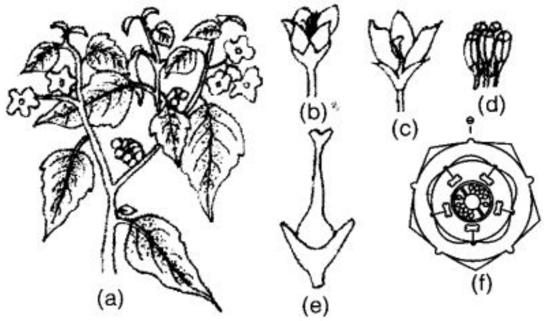


Fig. 5.25 *Solanum nigrum* (makoi) plant
(a) Flowering twig (b) Flower
(c) LS of flower (d) stamens (e) carpel
(f) Floral diagram

Economic: Importance with Examples

Plants belonging to the family-Solanaceae has their importance in the following fields

(i) Food The family-Solanaceae includes a number of vegetables and spice yielding plants.

For example., Solanum tuberosum (potato), Solanum melongena (brinjal), Lycopersicon esculentum (tomato), Physalis peruviana (ground cherry), Capscicum annuum (chillies), etc.

(ii) Tobacco Nicotiana tabacum and N. rustica . contain toxic alkaloid nicotine. It is used for chewing, smoking and snuff.

(iii) Medicines Atropa bellodona is used to obtain Bellodona and atropine. Bellodona is used for relieving pain and treating cough. Atropine is used for dilating eye pupil. Datura stramonium is used in asthma. Other medicinal plants are Solanum xanthocarpum, Withania somnifera, Hyoscymus niger, etc.

Ornamentals The common ornamental plants are Cestrum nocturnum (Rat-ki-Rani), Petunia hybrida, Physalis peruviana (cape gooseberry), etc.

III. Family—Liliaceae

1. Systematic Position

Division	–	Spermatophyta
Sub-division	–	Angiospermae
Class	–	Monocotyledonae
Order	–	Liliflorae
Series	–	Coronarieae
Family	–	Liliaceae

2. Distribution
The family—Liliaceae (lily family) includes about 250 genera and 3700 species showing world wide distribution. About 200 species are available in India.

3. Habit
Usually perennial herbs, perenating by underground rhizomes, corms or bulbs, rarely shrubs or climbers (e.g., Smilax, Gloriosa, etc).

4. Vegetative Characters
(i) Root Generally adventitious, fibrous or fleshy (e.g., Asparagus).
(ii) Stem Herbaceous or woody. In some species underground bulbs or rhizomes.
(iii) Leaves Mostly basal, alternate, linear, exstipulate with parallel venation.

5. Floral Characters
(i) Inflorescence Mostly racemose, sometimes cymose, rarely solitary.
(ii) Flower Bracteate, pedicellate, actinomorphic, incomplete, bisexual, trimerous and hypogynous.
(a) Perianth Tepal six (3 + 3), often united into tube, valvate aestivation.
(b)polyandrous, opposite to tepals, sometimes epiphyllous.
(c) Gynoecium Tricarpellary, syncarpous, trilocular with many ovules, axile placentation, rarely unilocular with parietal placentation, ovary superior, style simple with three lobed stigma.
(d) Fruit A loculated capsule, rarely a berry.
(e) Seed Endospermic, embryo curved or straight.
(f) Floral Formula by

(iii) **Floral Formula** Br $\oplus$ ⚥ $\overset{\frown}{P_{(3+3)}}\, A_{(3+3)}\, \underline{G}_{(3)}$

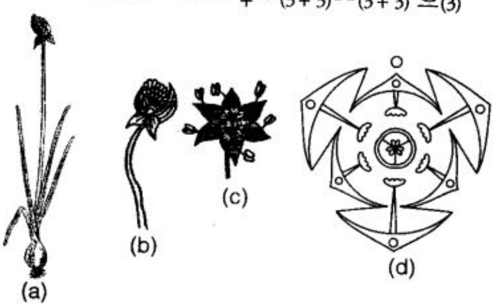


Fig. 5.26 *Allium cepa* (onion) plant (a) plant (b) Inflorescence (c) Flower (d) Floral diagram

Economic Importance with Examples
Plants belonging to this family has their importance in the following fields
(i) Food Allium cepa (onion), Allium sativum (garlic) young shoots and fleshy roots of Asparagus (shatavar) are used as vegetables.

(ii) Medicines Aloe leaves are used to cure piles, liver problems. Roots of Smilax are used as blood purifier. Raw onion is useful in constipation, diarrhoea and cholera. Dried corms of Colchicum autumnale (meadow saffron) are used against rheumatism and gout.

(iii) Ornamentals The common ornamentals are Ruscus, Yucca, Aloe, Asparagus, Gloriosa, Smilax, tulips, lilies, etc.
(iv) Fibres The fibre yielding plants of IHy family are Yucca filamentosa, Sansevieria roxburghiana, etc.

Morphology of Flowering Plants: MCQ Questions [150+

1. Roots that grow from any other part of the plant other than the radicle are called
(a) taproots
(b) adventitious roots
(c) prop roots
(d) epiphytic roots
SHOW ANSWER
(b) adventitious roots

2. A large globular root that tapers sharply at the lower end is called
(a) fusiform
(b) napiform
(c) conical
(d) tuberous
SHOW ANSWER
(b) napiform

3. The roots that have swellings at regular intervals are called
(a) nodulose
(b) fasciculated
(c) moniliform
(d) tuberous
SHOW ANSWER
(c) moniliform

4, Massive aerial roots present in a Banyan tree is
(a) fibrous
(b) respiratory
(c) epiphytic
(d) prop roots
SHOW ANSWER
(d) prop roots

5. Plants growing in swamps have roots that grow vertically upwards like conical spikes and have aerating pores. Such roots are called
(a) pneumatophores
(b) mycorrhizal
(c) conical
(d) assimilatory
SHOW ANSWER
(a) pneumatophores

6. The roots of the parasitic plant Cuscuta are of
(a) climbing
(b) prop or stilt
(c) mycorrhizal
(d) haustoria
SHOW ANSWER

7. A short, vertical underground stem that contains the food reserve is called
(a) rhizome
(b) bulb
(c) corm
(d) tuber
SHOW ANSWER
(c) corm

8. Ginger is an example of
(a) rhizome
(b) bulb
(c) corm
(d) tuber
SHOW ANSWER
(a) rhizome

9. A long green stem with long internodes growing horizontally on the soil surface is called
(a) runner
(b) sucker
(c) stolon
(d) offset
SHOW ANSWER
(a) runner

10. A short, green, flattened branch resembling a leaf arising from the axil of a reduced scale leaf is called
(a) phylloclade
(b) cladode
(c) phyllode
(d) stipule
SHOW ANSWER
(b) cladode

11. When many equally strong veins like midrib arise from the petiole towards the margin of the leaf forming a network, the leaf is said to
(a) reticulate pinnate
(b) reticulate palmate
(c) parallel pinnate
(d) parallel palmate
SHOW ANSWER
(b) reticulate palmate

12. In a pitcher plant, the pitchers are modified
(a) fruits
(b) branches
(c) petioles
(d) leaves
SHOW ANSWER
(d) leaves

13. The sharp spines in cactus are modified
(a) leaflets
(b) leaves
(c) branches
(d) thorns
SHOW ANSWER
(b) leaves

14. The tendrils of the pea plant Pisum are modifications of
(a) branch
(b) axillary bud
(c) leaf
(d) apical bud
SHOW ANSWER
(c) leaf

15. When the leaflets are joined together at a common point at the petiole, the leaf is
(a) simple leaf
(b) pinnately compound leaf
(c) palmately compound leaf
(d) a branch
SHOW ANSWER
(c) palmately compound leaf

16. Phyllotaxy refers to an arrangement of
(a) phloem in a vascular bundle
(b) leaves on a branch
(c) veins in a leaf
(d) axillary buds in a plant
SHOW ANSWER
(b) leaves on a branch

17. A flower that has only stamens is called
(a) unisexual flower
(b) bisexual flower
(c) complete flower
(d) neuter flower
SHOW ANSWER
(a) unisexual flower

18. A flower with a superior ovary is called
(a) hypogynous
(b) perigynous
(c) epigynous
(d) syncarpous
SHOW ANSWER
(a) hypogynous

19. An inflorescence with the main axis elongated bearing flowers in a pendulous axis is called
(a) raceme
(b) spike
(c) catkin
(d) spadix
SHOW ANSWER

(c) catkin

20. On maturity, an ovule forms a

(a) seed
(b) fruit
(c) embryo sac
(d) endosperm
SHOW ANSWER
(a) seed

21. Pineapple is an example of

(a) simple fruit
(b) aggregate fruit
(c) multiple fruits
(d) false fruit
SHOW ANSWER
(c) multiple fruits

22. Monocarpellary, superior ovary is found in

(a) Liliaceae
(b) Poaceae
(c) Solanaceae
(d) Fabaceae
SHOW ANSWER
(d) Fabaceae

23. Tricarpellary, the syncarpous condition is found in

(a) Liliaceae
(b) Poaceae
(c) Solanaceae
(d) Asteraceae
SHOW ANSWER
(a) Liliaceae

24. Family Fabaceae has

(a) 4 corolla
(b) 5 corolla
(c) 6 corolla
(d) none of these
SHOW ANSWER
(b) 5 corolla

25. Which of the following plant parts elongates directly and leads to the formation of primary roots?

(a) bud
(b) radicle
(c) plumule
(d) root hair
SHOW ANSWER
(b) radicle

26. The primary roots and their branches constitute the

(a) fibrous root system
(b) taproot system
(c) adventitious root system
(d) all of the above
SHOW ANSWER
(b) taproot system

27. The fibrous root system is found in

(a) monocotyledonous plants
(b) dicotyledonous plants
(c) bryophytes
(d) gymnosperms
SHOW ANSWER
(a) monocotyledonous plants

28. Roots develop from parts of the plant other than radicle are called

(a) taproots
(b) fibrous roots
(c) adventitious roots
(d) nodular roots
SHOW ANSWER
(c) adventitious roots

29. Root hairs develop from

(a) region of maturation
(b) region of elongation
(c) region of meristematic activity
(d) root cap
SHOW ANSWER
(a) region of maturation

30. The part of the root which is most active in water absorption is called

(a) root cap
(b) maturation zone
(c) meristematic zone
(d) zone of elongation
SHOW ANSWER

(b) maturation zone

31. Fibrous roots develop in maize from

(a) upper nodes
(b) lower nodes
(c) upper internodes
(d) none of these
SHOW ANSWER

32. Prop roots of the banyan tree are meant for

(a) respiration
(b) absorption of water from the soil
(c) providing support to the big tree
(d) all of the above
SHOW ANSWER
(c) providing support to the big tree

33. Stilt roots occur in

(a) groundnut
(b) rice
(c) sugarcane
(d) wheat
SHOW ANSWER
(c) sugarcane

34. Pneumatophores are found in

(a) the vegetation which is found in marshy and saline lake
(b) the vegetation which is found in saline soil
(c) xerophytic condition
(d) hydrophytic condition
SHOW ANSWER
(a) the vegetation which is found in marshy and saline lake

35. Which of the following plants grow in swampy areas, where the roots come out of the ground and grow vertically upwards?

(a) Potato
(b) Opuntia
(c) Rhizophora
(d) Grass
SHOW ANSWER
(c) Rhizophora

36. Root differs from the stem in having

(a) nodes and internodes
(b) axillary buds
(c) multicellular hairs
(d) unicellular hairs
SHOW ANSWER
(d) unicellular hairs

37. Which of the following plant parts is generally green when young and later often become woody and dark brown?

(a) stem
(b) seed
(c) leaves
(d) flower
SHOW ANSWER
(a) stem

38. The regions of the stem where leaves are borne are called _ while _ are the portions between two _

(a) nodes, nodes, and internodes
(b) nodes, internodes, and nodes
(c) internodes, nodes, and nodes
(d) internodes, internodes, and nodes
SHOW ANSWER
(b) nodes, internodes, and nodes

39. Which of the following plant groups has underground stems?

(a) Potato, ginger, turmeric, Euphorbia, zaminkand
(b) Potato, ginger, turmeric, zaminkand, Colocasia
(c) Potato, Citrus, Opuntia, zaminkand, Colocasia
(d) Potato, cucumber, watermelon, zaminkand, Colocasia
SHOW ANSWER
(b) Potato, ginger, turmeric, zaminkand, Colocasia

40. Stem tendrils can be found in

(a) cucumber
(b) pumpkins

(c) grapevines
(d) all of these
SHOW ANSWER
(d) all of these

41. What is a modified stem used to protect plants from browsing animals?
(a) Tendrils
(b) Thorns
(c) Rhizome
(d) Tuber
SHOW ANSWER
(b) Thorns

42. Fibrous root in maize develop from
(a) Lower internodes
(b) Lower nodes
(c) Upper nodes
(d) None of the above
SHOW ANSWER
(b) Lower nodes

43. Which of the following plants have root pockets?
(a) Eichhorinia
(b) Capparis
(c) Opuntia
(d) Banyan
SHOW ANSWER
(a) Eichhorinia

44. In which of the following, the plants have all roots?
(a) Podostemon
(b) Lemna
(c) Wolffia
(d) Utricularia
SHOW ANSWER
(a) Podostemon

45. Food present in bulbil occurs in
(a) Root
(b) Stem
(c) Leaf base
(d) Petioles
SHOW ANSWER
(c) Leaf base

46. From which part of the root, root hairs develop?
(a) Region of maturation
(b) Region of elongation
(c) Meristematic region
(d) Region of root cap
SHOW ANSWER
(b) Region of elongation

47. Epiphytic roots are found in
(a) Indian rubber
(b) Orchid
(c) Tinospora
(d) Cuscuta
SHOW ANSWER
(b) Orchid

48. Potatoes are borne on
(a) Primary roots
(b) axil of scaly leaves
(c) Lateral roots
(d) Adventitious roots
SHOW ANSWER
(b) axil of scaly leaves

49. Some plants have rhizomes and roots as underground structures. Which characteristics of rhizome would distinguish them from roots?
(a) Rhizomes are thicker than roots
(b) Rhizomes have scaly leaves
(c) Rhizome are thinner than roots
(d) None of the above
SHOW ANSWER
(b) Rhizomes have scaly leaves

50. Sweet potato is a modification of
(a) Primary root
(b) leaf
(c) underground root
(d) Adventitious root
SHOW ANSWER
(d) Adventitious root

51. Roots are differentiated into adventitious roots by their
(a) Function

(b) appearance
(c) place of origin
(d) position
SHOW ANSWER
(c) place of origin

52. Winged petiole is found in
(a) citrus
(b) acacia
(c) radish
(d) peepal
SHOW ANSWER
(a) citrus

53. In one of the following the stem performs the function of storage and propagation
(a) Ginger
(b) Wheat
(c) Radish
(d) Groundnut
SHOW ANSWER
(a) Ginger

54. Leaves are attached to the stem at
(a) Apical meristem
(b) Internode
(c) Nodes
(d) Axillary meristem
SHOW ANSWER
(c) Nodes

55. Phyllotaxy refers to
(a) Arrangement of leaves on the stem
(b) Folding leaf in the bud
(c) (a) & (b) both
(d) None of the above
SHOW ANSWER
(a) Arrangement of leaves on the stem

56. Plants with jointed stem and hollow internodes are known as
(a) Clums
(b) Scape
(c) Ephemerals
(d) Lianas
SHOW ANSWER
(a) Clums

57. Bulbils take part in
(a) Sexual reproduction
(b) Respiration
(c) Transpiration
(d) Vegetative reproduction
SHOW ANSWER
(d) Vegetative reproduction

58. The stem is very much reduced in
(a) Tuber
(b) Bulb
(c) Corm
(d) Rhizome
SHOW ANSWER
(b) Bulb

59. Turmeric is a stem and not a root because
(a) It stores food material
(b) It grows parallel to the soil surface
(c) It has nodes and internodes
(d) It has chlorophyll
SHOW ANSWER
(c) It has nodes and internodes

60. Grasses are examples of the following type of stem
(a) Suckers
(b) Runners
(c) Stolon
(d) Rhizomes
SHOW ANSWER
(b) Runners

61. Red root is the name of
(a) Carrot
(b) Sweet potato
(c) Potato
(d) Beetroot
SHOW ANSWER
(d) Beetroot

62. Tiny sacs or bladders are found in
(a) Utriculariya
(b) Salvinia

(c) nepenthes
(d) Hydrilla
SHOW ANSWER
(a) Utriculariya

63. Which would do maximum harm to a tree? The loss of
(a) Half of its branches
(b) All of its leaves
(c) Half of its flower
(d) Half of its bark
SHOW ANSWER
(b) All of its leaves

64. Smallest dicotyledonous parasitic plant of the world is
(a) Coryadalis nana
(b) Primula minutissina
(c) Arcethobium minustissimum
(d) Marsilea minuta
SHOW ANSWER
(c) Arcethobium minustissimum

65. Adventitious roots
(a) Develop from radical
(b) Develop from flower
(c) Develop from embryo
(d) Develop from any part of plant body except radical
SHOW ANSWER
(d) Develop from any part of plant body except radical

66. The arrangement of leaves on a stem is called
(a) Venation
(b) Vernation
(c) Phyllotaxy
(d) Axis
SHOW ANSWER
(c) Phyllotaxy

67. Stem modified into flattened photosynthetic structure is
(a) Phyllode
(b) Bulbil
(c) Phylloclade
(d) Tendril
SHOW ANSWER
(c) Phylloclade

68. Nodulated roots occur in
(a) Leguminoceae
(b) Solanaceae
(c) Malvaceae
(d) Papilionaceae
SHOW ANSWER
(a) Leguminoceae

69. Insectivorous plants catch insects for obtaining
(a) Na – K
(b) Taste
(c) Phosphorus
(d) Nitrogen
SHOW ANSWER
(d) Nitrogen

70. Petiole is modified into tendril in
(a) Passiflora
(b) Gloriosa
(c) Pisum
(d) clematis
SHOW ANSWER
(d) clematis

71. Thorn is a stem structure because it
(a) Develops from the trunk
(b) Develops from the apical bud
(c) modification of bank floral bud
(d) is pointed
SHOW ANSWER
(b) Develops from the apical bud

72. Vegetative reproduction of Agave occurs through
(a) Rhizome
(b) Stolon
(c) Bulbils
(d) Sucker
SHOW ANSWER
(c) Bulbils

73. What is the eye of a potato?
(a) Axillary bud
(b) Accessory bud
(c) Adventitious bud
(d) Apical bud
SHOW ANSWER
(a) Axillary bud

74. If a raceme inflorescence is branched, it is called?
(a) Umbel
(b) spike
(c) Cymose
(d) Panicle
SHOW ANSWER
(d) Panicle

75. Zig-zag development of inflorescence axis is an example of
(a) Helicoid cyme
(b) Scorpioid
(c) Umbel
(d) Compound umbel
SHOW ANSWER
a) Helicoid cyme

76. Opposite decussate phyllotaxy is found in
(a) Calotropis
(b) Mango
(c) Hibiscus
(d) Nerium
SHOW ANSWER
a) Calotropis

77. A brightly coloured bract-like covering associated with the banana inflorescence is called
(a) Spathe
(b) Scape
(c) Spiral
(d) Scapigeron
SHOW ANSWER
a) Spathe

78. Inflorescence is
(a) Number of flower present on an axis
(b) Arrangement of flowers on an axis
(c) Method of the opening of a flower
(d) Type of flower borne on a peduncle
SHOW ANSWER
b) Arrangement of flowers on an axis

79. In monocot male gametophyte is
(a) Megaspore
(b) Nucleus
(c) Microspore
(d) Tetrad
SHOW ANSWER
c) Microspore

80. A catkin of the unisexual flower is found in
(a) Mulberry
(b) Wheat
(c) Onion
(d) Grass
SHOW ANSWER
a) Mulberry

81. Flower is a
(a) Modified cone
(b) Modified spike
(c) Modified branch system
(d) Modified reproductive shoot
SHOW ANSWER
d) Modified reproductive shoot

82. Flowers are always present in
(a) Cryptogamous
(b) Pteridophytes
(c) Angiosperms
(d) Bryophytes
SHOW ANSWER
(c) Angiosperms

83. Floral formula represents
(a) number and arrangement of floral parts
(b) Number of flowers in an inflorescence
(c) Type of flowers in a family
(d) None of above
SHOW ANSWER

(a) number and arrangement of floral parts

84. From the life cycle point of view, the most important part of plants is

(a) Flower
(b) Leaf
(c) Stem
(d) Root
SHOW ANSWER
a) Flower

85. The vexillum, (standard) wings, and keel in pea flowers constitute

(a) Calyx
(b) Corolla
(c) Androecium
(d) Gynaecium
SHOW ANSWER
b) Corolla

86. Diadelphous condition is present on

(a) Citrus
(b) Bombyx
(c) Pisum
(d) Brassica
SHOW ANSWER
c) Pisum

87. The number of female flowers in a cyathium is

(a) One
(b) Two
(c) Three
(d) Many
SHOW ANSWER
a) One

88. The perianth is found in a flower in which

(a) Calyx and Corolla are not distinguishable
(b) Stamens are leaf like
(c) Corolla leaf-like but the calyx is colored
(d) None of the above
SHOW ANSWER

89. Stamens with free anthers but filaments fused into several groups are

(a) Polyadelphous
(b) Diadelphous
(c) Monadelphous
(d) Syngenesious
SHOW ANSWER
a) Polyadelphous

90. Pappus is a modification of

(a) Calyx
(b) Corolla
(c) Stamens
(d) Gynoecium
SHOW ANSWER
a) Calyx

91. Placentation in legumes is

(a) Basal
(b) Marginal
(c) Axile
(d) Free central
SHOW ANSWER
(b) Marginal

92. The leaves are modified into tendrils, hooks, pitcher, and bladder in the following plants respectively

(a) sweet pea, bignonia, Nepenthes, Utricularia
(b) sweet pea, bignonia, Utricularia, Nepenthes,
(c) Nepenthes , bignonia, sweet pea, Utricularia
(d) Utricularia, Nepenthes, bignonia, sweet pea
SHOW ANSWER
a) sweet pea, bignonia, Nepenthes, Utricularia

93. Leaf apex is modified into tendril in

(a) Smilax
(b) Gloriosa
(c) Australian acacia
(d) Pea

SHOW ANSWER
(b) Gloriosa
94. A fibrous root system is better adapted than a tap root system for
(a) Storage food
(b) Anchorage of the plant to soil
(c) Absorption of water and organic food
(d) Transport of water and organic food
SHOW ANSWER
(b) Anchorage of the plant to soil
95. Which is not a stem modification?
(a) Rhizome of Ginger
(b) Corm of Colocasia
(c) Pitcher of Nepenthes
(d) tuber of the potato
SHOW ANSWER
c) Pitcher of Nepenthes
96. A pair of insectivorous plants are
(a) Dionaea and Viscum
(b) Nepenthes and bladderwort
(c) Drosera and rafflesia
(d) Venus fly and Rafflesia
SHOW ANSWER
b) Nepenthes and bladderwort
97. A phyllode is a modified
(a) leaf
(b) stem
(c) root
(d) branch
SHOW ANSWER
a) leaf
98. An underground specialized shoot with a reduced disc-like stem covered by fleshy leaves is
(a) bulb
(b) Rhizome
(c) rhizophore
(d) bulbil
SHOW ANSWER
a) bulb
99. Stipular tendril modification is found in
(a) Smilex
(b) Pea
(c) Guava
(d) Mimosa pudica
SHOW ANSWER
a) Smilex
100. Viscum is
(a) total stem parasite
(b) total root parasite
(c) partial stem parasite
(d) partial root parasite
SHOW ANSWER
c) partial stem parasite
101. Root pocket does not occur in
(a) Ipomoea
(b) Mangrove plants
(c) trapa
(d) pistia
SHOW ANSWER
d) pistia
102. Phylloclades are
(a) leaf modification
(b) one internode and long stem
(c) modified petioles
(d) green succulent stem of indefinite growth
SHOW ANSWER
d) green succulent stem of indefinite growth
103. The bladder of Utricularia and Pitchers of nepenthes are modifications of
(a) leaves
(b) stems
(c) root
(d) flowers
SHOW ANSWER
a) leaves
104. Tallest gymnosperm
(a) sequoia
(b) Eucalyptus

(c) Pinus
(d) Rannuncoulus
SHOW ANSWER
a) sequoia

105. The "Eyes" of the potato tuber is
(a) Root buds
(b) Flower buds
(c) Shoot bud
(d) Axillary buds
SHOW ANSWER
d) Axillary buds

106. Vexillary aestivation is characteristic of the family
(a) Asteraceae
(b) Solanaceae
(c) Brassicaceae
(d) Fabaceae
SHOW ANSWER
d) Fabaceae

107. Mangrove plant live in
(a) Alpine Tundra
(b) Tundra
(c) Marshy areas along rivers
(d) Marshy areas along the seashore
SHOW ANSWER
(d) Marshy areas along the seashore

108. Succulents are likely to be found in
(a) Tropical rain forest
(b) Deciduous forest
(c) Deserts
(d) Tundra
SHOW ANSWER
(c) Deserts

109. In a compound umbel, each umbellate is subtended by
(a) Involucre
(b) Bracket
(c) Involucel
(d) Bracteole
SHOW ANSWER
(b) Bracket

110. In the monocotyledonous seeds, the endosperm is separated from the embryo by a distinct layer known as
(a) testa
(b) epithelial layer
(c) tegmen
(d) scutellum
(e) coleoptile
SHOW ANSWER
(b) epithelial layer

111. The fleshy receptacle encloses a number of
(a) Berries
(b) achene
(c) Unisexual flower
(d) Samaras
SHOW ANSWER
(c) Unisexual flower

112. The ovary is half inferior in flowers of
(a) Peach
(b) Cucumber
(c) Cotton
(d) Guava
SHOW ANSWER
(a) Peach

113. Which one of the following statements is correct?
(a) In tomato, fruit is capsule
(b) Seeds of orchids have oil-rich endosperm
(c) Placentation in primrose is basal
(d) Flower of tulip is a modified shoot.
SHOW ANSWER
(b) Seeds of orchids have oil-rich endosperm

114. Flowers are zygomorphic in
(a) Mustard
(b) Gulmohar
(c) Tomato
(d) Datura
SHOW ANSWER

(b) Gulmohar

115. Phyllode is present in

(a) Euphorbia

(b) Australian Acacia

(c) Opuntia

(d) Asparagus

SHOW ANSWER

(b) Australian Acacia

116. Cymose inflorescence is present in

(a) Sesbania

(b) Trifolium

(c) Brassica

(d) Solanum

SHOW ANSWER

(d) Solanum

117. The seed can be defined as

(a) An immature embryo protected by coats

(b) A mature ovule with a dormant embryo with enough reserve food and a protective coating.

(c) A mature spore with enough reserve food and protective coatings

(d) A mature ovary with reserve food and protective coverings

SHOW ANSWER

(b) A mature ovule with a dormant embryo with enough reserve food and a protective coating

118. In the maize grain, the starchy food is stored in

(a) Cotyledons

(b) Coleoptile

(c) Aleurone layer

(d) Endosperm

SHOW ANSWER

(d) Endosperm

119. Which one of the following is not fruit?

(a) Cabbage

(b) Apple

(c) Watermelon

(d) Tomato

SHOW ANSWER

(a) Cabbage

120. What is the edible part of Mango?

(a) Epicarp

(b) Mesocarp

(c) Endocarp

(d) Thalamus

SHOW ANSWER

(b) Mesocarp

121. A fruit in which the fruit wall (pericarp) and seed coat have got fused is called

(a) Legume

(b) caryopsis

(c) nut

(d) drupe

SHOW ANSWER

(b) caryopsis

122. A composite or multiple fruits develop from

(a) Polycarpellary ovary

(b) Bicarpellary and syncarpous ovary

(c) Apocarpous ovary

(d) Inflorescence

SHOW ANSWER

(d) Inflorescence

123. Wheat grain is an example of :

(a) Achene

(b) Caryopsis

(c) Nut

(d) Follicle

SHOW ANSWER

(b) Caryopsis

124. Which fruit is a type of nut?

(a) Ground nut

(b) Oat

(c) Walnut

(d) Cashew nut

SHOW ANSWER

(d) Cashew nut
125. What is the edible part of coconut?
(a) Entire seed
(b) Fruit wall
(c) Endosperm
(d) None of the above
SHOW ANSWER
(c) Endosperm
126. Water inside a coconut is
(a) Liquid endosperm
(b) Liquid endocarp
(c) Liquid Mesocarp
(d) Liquid Nucleus
SHOW ANSWER
(a) Liquid endosperm
127. False fruit is a fruit that develops from:
(a) Ovary
(b) Any part of the flower except the ovary
(c) Aporcarpous carpellary
(d) Syncorpous carpellary
SHOW ANSWER
(b) Any part of the flower except the ovary
128. Fibers are found on the seeds of:
(a) Calotropis
(b) Gossypium
(c) Alstonia
(d) All of above
SHOW ANSWER
(d) All of above
129. Which is the correct pair for an edible part?
(a) Tomato – Thalamus
(b) Maize – Cotyledons
(c) Guava – Mesocarp
(d) Date palm- Pericarp
SHOW ANSWER
(b) Maize – Cotyledons
130. How many plants in the list given below have composite fruits that develop from an inflorescence?
Walnut, poppy, radish, pineapple, apple, tomato, mulberry.
(a) Five
(b) Two
(c) Three
(d) Four
SHOW ANSWER
(c) Three
131. A characteristic of angiosperm is
(a) Flower
(b) Root
(c) Seed
(d) All of these
SHOW ANSWER
(a) Flower
132. The capacity for vegetative reproduction is found in
(a) Leaves
(b) Roots
(c) Stem
(d) All of above
SHOW ANSWER
(d) All of above
133. _ are the vegetative organs of the flowering plants
(a) Root, stem, flower
(b) Leaves, stem, fruits
(c) Roots, leaves, flowers
(d) Roots, stem, leaves
SHOW ANSWER
(d) Roots, stem, leaves
134. A root can be differentiated from the stem because of the absence of
(a) Green colour
(b) Nods and internodes
(c) Hair
(d) Branches
SHOW ANSWER
(b) Nods and internodes

135. Which one of the following is not a characteristic of the root
(a) Presence of root tap
(b) Presence of unicellular hair
(c) Presence of chlorophyll
(d) Absence of buds
SHOW ANSWER
(c) Presence of chlorophyll

136. When the trunk is unbranched and bears a crown of leaves at its apex, it is known as
(a) Runner
(b) Sucker
(c) Caudex
(d) Culm
SHOW ANSWER
(c) Caudex

137. Parallel venation is a characteristic of
(a) Legumes
(b) Grasses
(c) Parasitic plants
(d) Xerophytic plants
SHOW ANSWER
(b) Grasses

138. Leaf morphology helps in
(a) Plant identification
(b) Plant classification
(c) None of these
(d) (a) & (b) both
SHOW ANSWER
(d) (a) & (b) both

139. When the stem or its branch ends into a floral bud
(a) Vegetative growth starts
(b) Reproductive growth starts
(c) Lateral branch is given out
(d) Apical growth is stimulated
SHOW ANSWER
(b) Reproductive growth starts

140. The root that grows from any part of the plant body other than the radical is called?
(a) Tap root
(b) Adventitious root
(c) Modified roots
(d) Aerial roots
SHOW ANSWER
(b) Adventitious root

141. _ require more than two growing seasons to complete their life cycle
(a) Annual
(b) Perennials
(c) Biennials
(d) Herbs
SHOW ANSWER
(b) Perennials

142. Modified stem of _ protect the plant from grazing animal
(a) Datura festuosa
(b) Aloe vera
(c) Gloriosa superba
(d) Carissa carandus
SHOW ANSWER
(d) Carissa carandus

143. Which of the following is actually not a flower?
(a) Shoe flower
(b) Sun flower
(c) Rose
(d) Pea
SHOW ANSWER
(b) Sun flower

144. The beauty of the Bougainvillea flower is
(a) Corolla
(b) Calyx
(c) Bracts
(d) Androecium
SHOW ANSWER
(c) Bracts

145. Flower in which the only set of one essential organ develops is called
(a) Unisexual

(b) Monoecious
(c) Dioecious
(d) Polygamous
SHOW ANSWER
(a) Unisexual

146. Individual components of Perianth are called
(a) Sepals
(b) Petals
(c) Tepals
(d) Brackets
SHOW ANSWER
(c) Tepals

147. Brinjal show which calyx
(a) Pappus
(b) Deciduous
(c) Caduceus
(d) Persistent
SHOW ANSWER
(d) Persistent

148. The hairs present in maize corn cob are
(a) Styles
(b) Stigma
(c) Seed hairs
(d) Modified hairs of bracts
SHOW ANSWER
(a) Styles

149. Seed is :
(a) Fertilized embryo
(b) Fertilized ovary
(c) Fertilized fruit
(d) Fertilized ovule
SHOW ANSWER
(d) Fertilized ovule

150. A pome fruit is said to be false because
(a) The pericarp is inconspicuous
(b) The endocarp is cartilaginous
(c) The fruit is present in fleshy edible thalamus
(d) The fruit is derived from an inferior ovary
SHOW ANSWER
(c) The fruit is present in fleshy edible thalamus

151. Geocarpic fruit is
(a) Potato
(b) Pea nut
(c) Onion
(d) Garlic
SHOW ANSWER
(b) Pea nut

152. The unifoliate leaf is found in
(a) Pea
(b) Citrus
(c) Royal palm
(d) Oil palm
SHOW ANSWER
(b) Citrus

153. Drupe has
(a) hard Epicarp
(b) hard endocarp
(c) hard mesocarp
(d) no epicarp
SHOW ANSWER
(b) hard endocarp

154. Which of these characters do not belong to Compositae?
(a) Ligulate ray flowers
(b) Basal ovules
(c) Syngenesious stamens
(d) Five lobed stigma
SHOW ANSWER
(d) Five lobed stigma

155. An inflorescence always forms a
(a) Multiple or composite fruit
(b) Simple fruit
(c) Dry dehiscent fruit
(d) Aggregate fruit
SHOW ANSWER
(a) Multiple or composite fruit

156. Which of the following pairs is not correct?
(a) Corymb – Candytuft
(b) Capitulum – sunflower
(c) Catkin – Mulberry
(d) Raceme – Wheat
SHOW ANSWER

157. Find the incorrect match
(a) Stilt root – turnip
(b) Taproot – carrot
(c) Adventitious root – sweet potato
(d) Prop root- banyan tree
SHOW ANSWER
(a) Stilt root – turnip

158. Which of the following is a wrong pairing?
(a) Raceme – Mustard
(b) spike – Achyranthus
(c) compound umbel – Onion
(d) spadix – Musa
SHOW ANSWER
(c) compound umbel – Onion

159. The correct match for the edible part of the fruit is
(a) Guava – pericarp with the thalamus
(b) Tomato – thalamus
(c) Maize – cotyledon
(d) Date palm – epicarp
SHOW ANSWER
(a) Guava – pericarp with the thalamus

NCERT Solutions For Class 11 Biology Morphology of Flowering Plants

Topics and Subtopics in **NCERT Solutions for Class 11 Biology Chapter 5 Morphology of Flowering Plants:**

Section Name	**Topic Name**
5	Morphology of Flowering Plants
5.1	The Root
5.2	The Stem
5.3	The Leaf
5.4	The Inflorescence
5.5	The Flower
5.6	The Fruit
5.7	The Seed
5.8	Semi-technical Description of a Typical Flowering Plant
5.9	Description of Some Important Families
5.10	Summary

Morphology of Flowering Plants 0777 023 444

TEXTBOOK QUESTIONS SOLVED

1.What is meant by modification of root? What type of modification of root is found in the:
(a) Banyan tree
(b) Turnip
(c) Mangrove trees

Soln. Roots of some plants change their shape and structure and become modified to perform certain functions other than absorption and conduction of water and minerals. It is called modification of roots. Roots are modified for support, storage of food and respiration, etc.
(a) Root modification in banyan tree : In banyan tree, the root modifies to form prop roots. Prop roots arise from branches and enter the soil. Thus, they provide mechanical support to densely branched, huge trees.
(b) Root modification in turnip : The
modification of root found in turnip is napiform for food storage. The upper portion of these fleshy roots is inflated or swollen which tapers towards the lower end.
(c) Root modification in mangrove trees : In mangrove plants, i.e., plants growing in saline marshes, the branches of tap root come out of the ground and grow vertically upwards showing negative geotropism. These roots are called pneumatophores. They help to get oxygen for respiration.

2.Justify the following statements on the basis of external features:
(i) Underground parts of a plant are not always roots.
(ii) Flower is a modified shoot.

Soln. (i) Underground parts of plant are not always roots because sometimes the stem also becomes underground and gets modified into various forms to perform different functions of storage, vegetative propagation, perennation, etc. Underground modifications of stems are tuber, rhizome, corm and bulb. The underground stems can be distinguished from roots externally by the presence of nodes and internodes, axillary buds, scale leaves etc. and by absence of root cap and root hairs.
(ii) Flower is the reproductive part of the angiospermic plant and it is defined as the modified shoot because (a) like shoot, flower develops from an axillary or rarely terminal bud. (b) flowers may get modified into fleshy buds or bulbils, (c) A transition from foliage leaves to floral leaves is found in Paeonia. (d) Nymphaea

shows transition from sepals to petals and petals to stamens, (e) In Passiflora and Cleome long intemodes occur below gynoecium and stamens.

3.How is a pinnately compound leaf different from a palmately compound leaf?

Soln. The compound leaves may be of two types, pinnately compound leaf and palmately compound leaf. In pinnately compound leaf, a number of leaflets are present on a common axis, the rachis, which represents the midrib of the leaf as in neem. Pinnately compound leaf may be of different types as unipinnate, bipinna te, tripinna te and decompound. In palmately compound leaf, the leaflets are attached at a common point, i.e., at the tip of petiole, as in silk cotton. Palmately compound leaf may be of different types as unifoliate, bifoliate, trifoliate, quadrifoliate and multifoliate.

4.Explain with suitable examples the different types of phyllotaxy.

Soln. Phyllotaxy is the pattern of arrangement of leaves on the stem or branch. It is usually of three types – alternate, opposite and whorled. In alternate type of phyllotaxy, a single leaf arises at each node in alternate manner, as in china rose, mustard and sunflower plants. In opposite type, a pair of leaves arises at each node and lie opposite to each other as in Calotropis and guava plants.
If more than two leaves arise at a node and form a whorl it is called whorled phyllotaxy as in Alstonia.

5.Define the following terms:
(a) aestivation (b) placentation
(c) actinomorphic (d) zygomorphic
(e) superior ovary (f) perigynous flower (g) epipetalous stamen.

Soln. (a) Aestivation : The mode of arrange¬ment of accessory floral organs (sepals and petals) in relation to one another in floral bud is known as aestivation. The main type of aestivation are valvate, twisted, imbricate, and vexillary.
(b) Placentation : The arrangement of ovules within the ovary is known as placentation. The placentation are of different types namely, marginal, axile, parietal, basal, and free central.
(c) Actinomorphic : When flower can be divided into equal radial halves in any radial plane passing through the centre, it is said to be actinomorphic, e.g., mustard, Datura etc.
(d) Zygomorphic : When a flower can be divided into two similar halves only in one particular vertical plane, it is said to be zygomorphic, e.g., pea, gulmohar, bean, Cassia.

(e) Superior ovary : In hypogynous flower, the gynoecium occupies the highest position while the other parts are situated below it. The ovary in such flowers is said to be superior, e.g., mustard, brinjal.
(f) Perigynous flower: If gynoecium is situated in the centre and other parts of the flower are
located on the rim of the thalamus almost at the same level, it is called perigynous. Here ovary is half superior, e.g., peach, plum.
(g) Epipetalous stamen : When stamens are attached to the petals, they are called epipetalous stamens e.g., brinjal.

6.Differentiate between
(a) Racemose and cymose inflorescence
(b) Fibrous root and adventitious root
(c) Apocarpous and syncarpous ovary
Soln.
(a) Differences between racemose and cymose inflorescence are as follows:

	Racemose inflorescence	Cymose inflorescence
(i)	The main axis continues to grow.	The main axis terminates in a flower.
(ii)	Growth is unlimited.	Growth is limited.
(iii)	The flowers are borne in an acropetal succession.	Flowers are borne in a basipetal succession.
(iv)	The grouping of flowers is less common and arrangement of flowers in a group is centripetal.	The grouping of flower is more common and arrangement of flowers in a group is centrifugal.

(b) Differences between fibrous and adventitious roots are as follows :

	Fibrous root	Adventitious root
(i)	It occurs in place of tap root system at the base of main stem.	Roots arise from various parts of the plant other than the radicle.
(ii)	The roots are thin and fibrous.	The roots can be thin, thick or variously modified.
(iii)	The root system is underground.	It can be underground or above ground.
(iv)	Fibrous root system takes part in fixation of plant, absorption of water and mineral salts etc.	It performs several functions like clinging, support, storage, reproduction, fixation, absorption, etc.

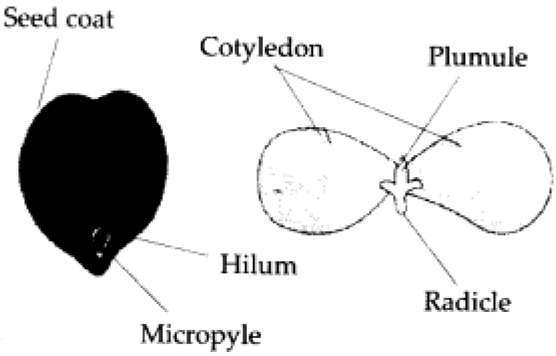
(c) Differences between apocarpous and syncarpous ovary are as follows :

	Apocarpous ovary	Syncarpous ovary
(i)	The flower has several free ovaries.	There is a single ovary.
(ii)	It is always unilocular.	It can be unilocular or multilocular.
(iii)	On maturity it forms fruitlet of aggregate type.	On maturity it forms a simple fruit.

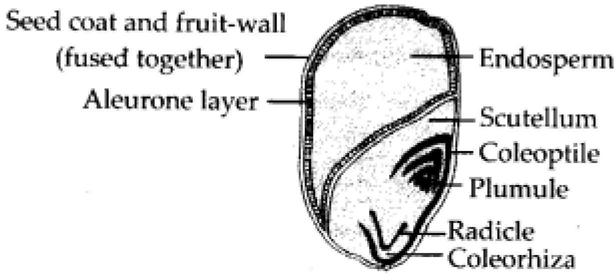
7.Draw the labelled diagram of the following:
(i) Gram seed (ii) V. S. of maize seed.

Soln.

(i) Gram seed.



(ii) V.S. of maize seed.



8. Describe modifications of stem with suitable examples.

Soln. Stems are modified to perform different functions. Underground stems of some plants are modified to store food in them. They also act as organs of perennation to tide over conditions unfavourable for growth. Different modifications of stem are :

(i) Underground modifications

(ii)Sub-aerial modifications

(iii)Aerial modifications

(i)Underground modifications of stem are discussed as follows:

(a)Tuber: It is the branch of main stem which accumulates or stores food in it and swells up, e.g., Solarium tuberosum (potato).

(b) Rhizome: It is a branched, prostrate horizontally growing stem having nodes and internodes. On the nodes sessile scale leaves are formed, e.g., Carina, Zingiber officinale (ginger), Curcuma domestica (turmeric) etc.

(c) Corm: This is a spherical,
branched, vertically growing thick underground stem with more diameter than length, e.g., Crocus sativus (saffron), Gladiolus, Colocasia esculenta (arvi) etc.

(d) Bulb: In bulb the stem is highly reduced and can be seen only as a disc-like structure bearing numerous fleshy scaly leaves, e.g., Allium cepa (onion), Allium sativum (garlic) etc.

(ii) Subaerial modifications : Subaerial part of stem grows horizontally on the ground while some part remains underground. Vegetative propagation takes place by means of these. They may be of following kinds.

(a) Runner: It grows prostrate on the surface of soil. It develops at the base of erect shoot called crown. A number of runners arise from one erect shoot which spread in different directions. Each runner has one or more nodes which bear scale leaves and axillary buds, e.g., Cynodon (doob grass).

(b) Stolon: The nodes of horizontally growing underground stem give rise to branches which come out of the soil, e.g., Fragaria (strawberry).

(c) Sucker: Suckers are formed from the node of underground stem. Sucker comes up obliquely in the form of leafy shoot, e.g., Mentha (mint).

(d) Offset: Stem consists of thick and short intemodes. The branches are formed from the main stem and upper portion of each branch bears a group of leaves while the lower portion bears the roots. Each branch is capable of growing as an independent plant after separating from the parent plant, e.g., Eichhornia (water hyacinth), Pistia, etc.

(iii)Aerial modifications : The aerial portion of stem is modified to perform different functions, e.g., climbing, protection, food manufacturing, etc. It may show following types of modifications:

(a) Twinners : The stem is long, flexible and sensitive which can coil around an upright support like a rope, e.g., Ipomoea, Convolvulus.

(b) Climbers : The stem is weak and flexible but is unable to coil around an upright support by itself. It requires the help of clasping or clinging structures. Accordingly, climbers are of four types : root climbers, e.g., Betel; tendril climber, e.g., Passiflora; scramblers, e.g., Bougainvillea and lianas, e.g., Bauhinia.

(c) Phylloclade: The stem performs the function of photosynthesis. The stem modifies into green fleshy leaf-like
structure having distinct nodes and intemodes. Leaves of such plants are reduced into spines in order to prevent loss of water, e.g., Opantia (prickly pear), Euphorbia.

(d) Cladode: It is similar to phylloclade with only one internode, e.g., Asparagus.

(e) Thorn: Stem is modified into stiff, pointed unbranched or branched structures which have lost their growing point and become hard, called as thorns, e.g., Bougainvillea,Pomegranate, Citrus, etc. They perform defensive function.

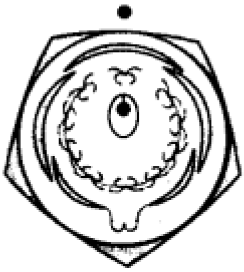
(f) Tendrils : These are thread like sensitive structures which can coil around a support and help the plant
in climbing, e.g., Cucurbita.

(g) Bulbils: In some plants vegetative buds or floral buds modify into a swollen structure called bulbil. It separates from the parent plant and on approach of favourable condition gives rise to a new plant, i.e., it is an organ of vegetative reproduction, e.g., Agave, Oxalis.

9.Take one flower each of the families Fabaceae and Solanaceae and write their semi-technical description. Also draw their floral diagram after studying them.

Soln. Family Fabaceae (e.g., Pisum sativum) Systematic position:
Class – Dicotyledoneae
Subclass- Polypetalae
Series – Calyciflorae
Order – Rosales
Family – Fabaceae
Vegetative characters:
Habit: herb. Root: tap, branched, with root nodules.
Stem: herbaceous, climbing.
Leaves : pinnately compound, leaf base pulvinate, stipulate, venation reticulate.
Floral characters:
Inflorescence: racemose.
Flower : bisexual, zygomorphic, irregular, hermaphrodite, white or pink, complete, hypogynous to perigynous.
Calyx : sepals five, gamosepalous, ascending, imbricate aestivation, campanulate calyx tube.
Corolla : petals five, polypetalous, vexillary aestivation, papilionaceous, consisting of a posterior standard or vexillum two lateral wings or alae, two anterior ones forming a keel.
Androecium : 10 stamens in two bundles (diadelphous) of (9) + 1, anthers dithecous (bilobed), basifixed, introrse.
Gynoecium : ovary superior, monocarpellary, unilocular with many ovules, marginal placentation, style bent and long, stigma simple and-hairy.
Fruit : legume; seeds one to many, non- endospermic.

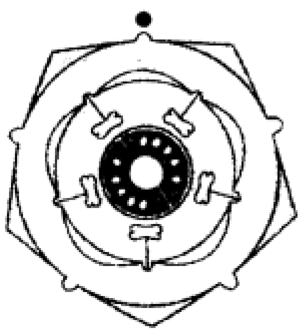
Floral formula : $\% ⚥ K_{(5)} C_{1+2+(2)} A_{(9)+1} \underline{G}_1$



Floral diagram of *Pisum sativum*

Family Solanaceae (e.g., Solanum nigrum) Systematic position:
Class Subclass Series Order Family
Vegetative characters:
Habit: herbs Stem : herbaceous, aerial, erect, cylindrical, branched.
Leaves: alternate, simple, exstipulate, venation reticulate.
Floral characters:
Inflorescence: cymose.
Flower : ebracteate, ebracteolate, bisexual, actinomorphic, white, hypogynous.
Calyx : sepals five, gamosepalous, persistent, valvate aestivation.
Corolla : petals five, gamopetalous, valvate. aestivation.
Androecium : stamens five, epipetalous, polyandrous, anthers large, bithecous and basifixed.
Gynoecium : bicarpellary, syncarpous,
ovary, obliquely placed carpels in the flower, bilocular, axile placentation, placenta swollen with many ovules.
Fruits : berry with persistent calyx.

Floral formula : Ebr Ebrl $\oplus ⚥ K_{(5)} \overset{\frown}{C_{(5)} A_{(5)}} \underline{G}_{(2)}$



Floral diagram of *Solanum nigrum*.

10. Describe the various types of placentations found in flowering plants.

Soln. Placenta is a parenchymatous cushion present inside the ovary where ovules are borne. The number, position, arrangement or distribution of placentae inside an ovary is called placentation. The placentation are of different types namely,

marginal, axile, parietal, basal and free central.
(i)Marginal placentation : The placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows, e.g., pea.
(ii)Axile placentation : When the placenta is axial and the ovules are attached to it in a multilocular ovary, the placentation is said to be axile, e.g., china rose, tomato and lemon.
(iii)Parietal placentation : The ovules develop on the inner wall of the ovary or on peripheral part. Ovary is one-chambered but it becomes two-chambered due to the formation of the false septum, e.g., mustard and Argemone.
(iv)Free central placentation : When the ovules are borne on central axis and septa are absent, as in Dianthus and primrose the placentation is called free central.
(v)Basal placentation: The placenta develops at the base of ovary and a single ovule is attached to it, as in sunflower, marigold.

11.What is a flower? Describe the parts of a typical angiosperm flower.
Soln. Flower is the reproductive unit in the angiosperms. It is meant for sexual reproduction. A typical flower has four different kinds of whorls arranged successively on the swollen end of the stalk or pedicel, called thalamus or receptacle. These are calyx, corolla, androecium and gynoecium.
Calyx and corolla are accessory organs, while androecium and gynoecium are reproductive organs. In some flowers like lily, the calyx and corolla are not distinct and are termed as perianth. Some flowers have both androecium and gynoecium and are termed hermaphrodite flowers while some flowers have only one of these two whorls.
Calyx : The calyx is the outermost whorl of the flower and its units are called sepals. Generally, sepals are green, leaf like and protect the flower in the bud stage. The calyx may be gamosepalous (sepals united) or polysepalous (sepals free).
Corolla : Corolla is composed of petals. Petals • are usually brightly coloured to attract insects for pollination. Like calyx, corolla may also be free (polypetalous) or united (gamopetalous). The shape and colour of corolla vary greatly in plants. Corolla may be tubular, bell-shaped, funnel-shaped or wheel-shaped.
Androecium : Androecium is the male reproductive part of the flower. It is composed of stamens. Each stamen which represents the male reproductive organ consists of a stalk or a filament and an anther. Each anther is usually bilobed and each lobe has two chambers, the pollen-sacs. The pollen grains are produced in pollen-sacs. A sterile stamen is called staminode.
Gynoecium : Gynoecium is the female reproductive part of the flower and is made up of one or more carpels. A carpel consists of three parts namely stigma, style

and ovary. Ovary is the enlarged basal part, on which lies the elongated tube, the style. The style connects the ovary to the stigma. The stigma is usually at the tip of the style and is' the receptive surface for pollen grains. Each ovary bears one or more ovules attached to a flattened, cushion-like placenta. When more than one carpel is present, they may be free (as in lotus and rose) and are called apocarpous. They are termed syncarpous when carpels are fused, as in mustard and tomato. After fertilisation, the ovules develop into seeds and the ovary matures into a fruit.

12. How do the various leaf modifications help plants?

Soln. Leaves perform various functions besides photosynthesis and thus they are modified into different forms such as –

(i)Leaf tendrils: The different parts of a leaf are modified into tendrils which help the plant in climbing up. Parts of leaf modified into tendrils include stipules e.g., Smiiax ; petiole e.g., Clematis ; leaf apex e.g., Gloriosa ; leaflets e.g., Pisum; whole leaf e.g., Lathyrus.

(ii)Leaf spines: Either for the protection of plant or to lessen the rate of transpiration in xerophytic plants, the leaves modify into sharp, pointed spines. Parts of leaf modified into leaf spines include stipules e.g., Zizyphus; leaf margins e.g., Argemone; leaf apex e.g.r Yucca; entire leaf e.g., Berberis.

(iii)Phyllode: Petioles modify into leaf¬like green, photosynthesising structure e.g., Parkinsonia, Acacia auriculiformis.

(iv)Scale or protective leaves : The leaves modify into hard scaly leaves which protect the vegetative bud by covering them, e.g., Ficus, Artocarpus, Casuarina, etc.

(v) Leaf hooks : They help in climbing e.g., Bignonia.

(vi)Leaf roots : A leaf transforms into roots for balancing on water e.g., Salvinia.

(vii)Leaf pitchers : Leaf is modified into pitcher e.g., Nepenthes (insectivorous), Dischidia (non-insectivorous).

(viii)Leaf bladder: The leaves modify to form bladder like structure which trap insects and then it is closed by a valve present on the mouth of bladder e.g., Utricularia (bladderwort).

(ix) Leaf tentacles: The leaf of sundew plant, Drosera bear minute hairs which have shinning, sticky substance at their tips (tentacles). When any insect sits on the leaf, it is covered by these hairs.

13. Define the term inflorescence. Explain the basis for the different types of inflorescence in flowering plants.

Soln. The arrangement of flowers on the floral axis is termed as inflorescence. A flower is a modified shoot wherein internodes do not elongate and the axis gets condensed. The apex produces different kinds of floral appendages laterally at successive nodes instead of leaves. When a shoot tip transforms into a flower, it is always solitary. Depending on whether the apex gets converted into a flower or continues to grow, two major types of inflorescence are defined – racemose and cymose. In racemose type of inflorescence the main axis continues to grow, the flowers are borne laterally in acropetal succession. In cymose type of inflorescence the main axis terminates in a flower, hence is limited in growth. The flowers are borne in a basipeta! order.

14. Write the floral formula of an actinomorphic, bisexual, hypogynous flower with five united sepals, five free petals, five free stamens and two united carples with superior ovary and axile placentation.

Soln. The floral formula for actinomorphic, bisexual, hypogynous flower with five united sepals, five free petals, five free stamens and two united carples with superior ovary and
axile placentation is:

15.Describe the arrangement of floral members in relation to their insertion on thalamus.

Soln. In a typical flower, the floral members like calyx, corolla, androecium and gynOecium are arranged over the thalamus! Based on the position of calyx, corolla and androecium in respect to ovary on thalamus, the flowers are described as hypogynous, perigynous and epigynous ones. In the hypogynous flower the gynoecium occupies the highest position while the other parts are situated below it. The ovary in such flowers is said to be superior, e.g., mustard, china rose and brinjal. If gynoecium is situated in the centre and other parts of the flower are located on the rim of the thalamus almost at the same level, it is called perigynous. The ovary here is said to be half inferior or sub superior, e.g., plum, rose, peach. In epigynous flowers, the margin of thalamus grows upward enclosing the ovary completely and gets fused with it; the other parts of flower arise above the ovary. Hence, the ovary is said to be inferior as in flowers of guava and cucumber, and the ray florets of sunflower.

Anatomy of Flowering Plants Class 5 Notes Biology

This chapter introduces the internal structure and functional organisation of higher plants. The study of internal structure of plant is called anatomy.

1. Tissues and Tissue Systems

The plants have cells as their basic unit. Compared to animal cells, plant cells have a cell wall consisting of a primary cell wall, secondary cell wall and middle lamella. To make the plant structure, the cells with common function, joint together and form a complex structure, called tissue.

Tissues

A tissue is a group of cells having a common origin and usually perform a common function. A plant body is made up of different kinds of tissues. Generally, the cells of a tissue share the same origin in the embryonic stage. The tissues help in body function by allowing division of labour, e.g., In leaf, various cells commonly perform the function of photosynthesis.

The plant tissues can be divided into two main types I. Meristematic tissues II. Permanent tissues

I. Meristematic Tissues

The growth in plants is mainly restricted to specialised regions of active cell division called meristems (Gk. Memtar—divided). A meristematic tissue is an undifferentiated mass of cells, that is in a continuous state of division or retain their power of division. These tissues divide to form new cells which differentiate to give rise to permanent tissues.

Characteristics of Meristematic Tissue

The characteristics of meristematic tissue are listed below

(i) They are living and contain undifferentiated mass of rapidly dividing cells.

(ii) The shape of cells is spherical, polygonal or rectangular.

(iii) The cells are compactly arranged without intercellular spaces and are interconnected by plasmodesmata.

(iv) Nucleus is large and present either in interphase or in divisional stages.

(v) Cell wall is thin with only a primary wall made up of cellulose. Secondary wall is absent.

Classification of Meristematic Tissue

Meristem can be classified broadly based on three ways, i.e., position in the plant body, functions and origin.

Classification Based on Position

Meristems can be divided into three types, based on their position in the plant body. These are as given below

(a) Apical Meristems The meristems which occurs at the tips of root and shoot and produce primary tissues are called apical meristems. The Root Apical Meristem (RAM) occupies the tip of a root while, the Shoot Apical Meristem (SAM) occupies the distinct most region of the stem axis.

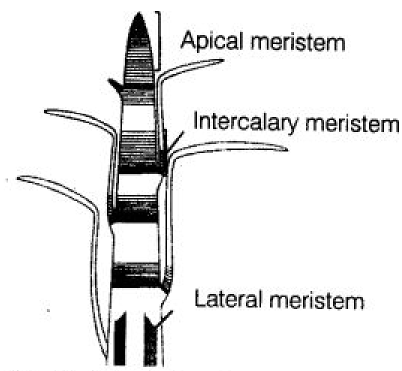


Fig. 6.1 Position of meristems in LS of a shoot

During the formation of leaves and elongation of stem, some cells, left behind from shoot apical meristem, constitute the axillary bud. These buds are present in the axil of leaves and are capable of forming a branch or a flower.

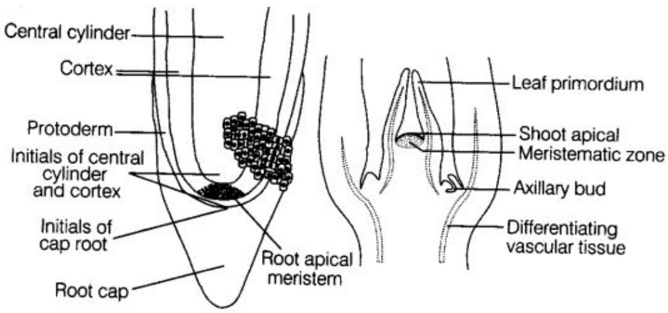


Fig. 6.2 Apical meristem (a) Root (b) Shoot

(b) Intercalary Meristems The meristem which occurs between mature tissues is known as intercalary meristem. They occur in grasses and regenerate parts removed by the grazing herbivores.

Both apical and intercalary meristems are primary meristems because they appear early in life of a plant and contribute to the formation of the primary plant body. These meristems are usually responsible for growth in length and present mostly at the base of node (e.g., Mint), base of internode (e.g., Stem of wheat and grasses) or at the base of leaf (e.g., Pinus).

(c) Lateral Meristems The meristems that occurs in the mature regions of roots and shoots of many plants. These meristems produce woody axis and appear later than primary meristem is called the secondary or lateral meristem.

They are cylindrical meristems. Some examples of lateral meristems are fascicular vascular cambium, interfascicular cambium and cork cambium. These are responsible for producing the secondary tissues.

Classification Based on Functions

The meristems are also classified on the basis of their functions as

(a) Protoderm It is the outermost portion of the primary meristem found at the apex of the stem and root. It develops into epidermis.

(b) Procambium It develops into primary vascular tissues. It forms the isolated strands of elongated cells, very near to the central region.

(c) Ground Meristem It develops into the ground tissue. The cells are thin-walled, living and isodiametric. In the later stages of growth, they become differentiated into hypodermis, cortex, endodermis, pericycle, medullary rays and pith.

Classification Based on Origin

The meristems are grouped on the basis of origin as

(a) Primary Meristems These meristems are derived during the early embyonic stages. They divide rapidly and differentiated into primary permanent tissues which make the fundamental structure of the plant body. They are mainly found in the growing apical regions of the root and shoot.

(b) Secondary Meristems These meristems appears in later stage of development in the plant body. They lie lateral in position in both the stem and root. Some primary permanent tissues acquire the power of division and become meristematic. These tissues dedifferentiate and form secondary meristems. Some examples of secondary meristems are cork cambium and interfascicular cambium. They allow secondary growth in tissues.

II. Permanent Tissues

The meristematic cells gradually differentiate and become mature or permanent. The permanent tissues actually composed of cells in which the growth has stopped.

Permanent tissues can be divided into two types

1. Simple Permanent Tissues

The permanent tissues having all cells similar in structure and function are called simple tissues. These are groups of homogenous cells which perform the same function.

i. Parenchyma

It is a living, simple permanent tissue composed of thin-walled cells. Parenchyma (Para-beside; enchein – to pour) is also called primary tissue or ground tissue. It is present in cortex, pith, palisade, mesophyll and some other parts of flower. It is mostly produced by the ground tissue. The parenchyma terms the major component within the organs.

The characteristic features of parenchyma are as follow

(a) The cells are thin-walled, less spherical and polyhedral in shape, these are generally isodiametric.

(b) The cell wall composed of cellulose, hemicellulose and pectin.

(c) Cells have a large central vacuole, peripheral cytoplasm with a nucleus.

(d) The cells may be either closely packed or have small intercellular spaces.

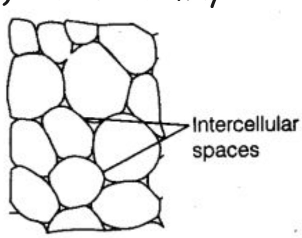


Fig. 6.3 Parenchyma

The parenchyma can be further classified as

- Chlorenchyma specialised for photosynthesis.
- Aerenchyma forms a connected air system throughout the entire plant.
- Storage parenchyma store sugars, protein granules, oil drops, etc.
- Xylem parenchyma helps in the conduction of water.
- Phloem parenchyma help in the translocation of food.

- Stellate parenchyma star-shaped parenchymatous tissue with large air spaces.

Different functions performed by parenchyma are

(a) These helps in storage of food, water and air,

(b) The vital activities like photosynthesis, respiration and conduction are carried out by parenchyma.

(c) It helps in wound healing, grafting, etc., and also provides buoyancy in aquatic plants.

(d) Parenchyma cells associated with xylem and phloem help in conduction of water, and food materials.

(e) These cells can dedifferentiate, acquire the power of division to form secondary meristem which produce secondary tissues.

ii. Collenchyma

Collenchyma (Gr. Colla – glue; enchyma – an infusion) is a simple, living mechanical tissue. Its cells composed of more or less elongated cells with thick, primary non-lignified walls. Intercellular spaces are found to be absent.

The characteristic features ofcollenchymatous tissues are listed below

(a) It is present only in the aerial parts of the plant body.

(b) It is found either as a homogeneous layer or in patches.

(c) Collenchyma consists of cells' which are much thickened at the corners due to a deposition of cellulose, hemicellulose and pectin. id) The cells may be oval, spherical or polygonal and often contain chloroplasts.

(e) These cells assimilate food, when they contain chloroplasts.

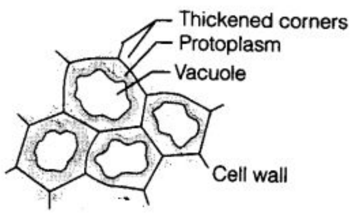


Fig. 6.4 Collenchyma

Based on pectinisation of the cell wall, there are three types of collenchyma

(a) Angular collenchyma

(b) Lamellar collenchyma

(c) Lacunar collenchyma

Different junctions performed by collenchyma are

(a) It provides mechanical support to the growing parts of the plant, such as young stem and petiole of a leaf.

(b) Collenchyma cells are capable of photosynthesis, as they contain chloroplasts.

iii. Sderenchyma

The sderenchyma (Gr. Sclerous—hard; enchyma—an infusion) consists of long, narrow cells with thick and lignified cells walls having a few or numerous pits.

The characteristic features ofsclerenchymatous cells are

(a) Cells are long or short, narrow, thick-walled and lignified.

(b) They possess hard and extremely thick secondary walls due to uniform deposition of lignin.

(c) These are dead cells and do not perform any metabolic function.

(d) They show different types of lignin depositions and also have pits.

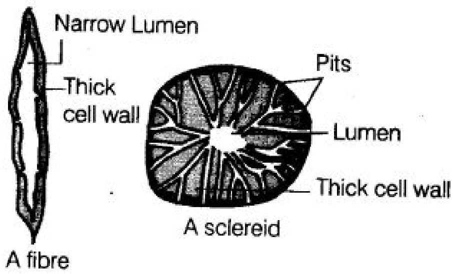


Fig. 6.5 Sclerenchyma

The sclerenchymatous cells may be divided into two types

(a) Sclereids These are short or irregular, spherical, oval or cylindrical sclerenchymatous cells. The walls are very thick, irregular and the lumen is very narrow. The walls show simple pits. These are commonly found in the fruit wall of nuts, pulp of the fruits, like-guava, pear and sapota, seed coats of legumes and leaves of tea.

(b) Sclerenchymatous Fibres These are thick-walled, elongated and pointed cells, generally occurring in groups, in various parts of the plant.

Different functions performed by sderenchyma are

(a) It provides mechanical strength and support.

(b) Surface fibres help in dispersal of seeds.

2. Complex Permanent Tissues

Complex permanent tissues are a group of more than one type of cells having common origin and working together as a unit.

The main complex tissues in vascular plants are xylem and phloem.

Xylem

Xylem (Gr. Xylos — wood) is a complex permanent tissue which conducts water and mineral nutrients upwards from the root to the leaves.

The xylem tissues are composed of four components

a. Tracheids These are elongated, tubular and primitive cells with tapering end walls. They are dead cells and do not contain protoplasts. The inner layers of the

cell walls have thickenings which vary in form. The end of the tracheids are tapering, blunt or chisel like. These are constituents of xylem of primitive plants. These are found in pteridophytes and gymnosperm tracheids may be classified as annular or helical, spiral and scalariform or pitted.
The tracheids conduct water and dissolved mineral elements from roots to leaves. They also provide mechanical support.
b. Vessels These are long, cylindrical, tube-like structures made up of many cells called vessel members, each with lignified walls and a large central cavity.
The vessel cells are also devoid of protoplasm. The vessel members are interconnected through perforations in their common walls. The presence of vessels is a characteristic feature of angiosperms.

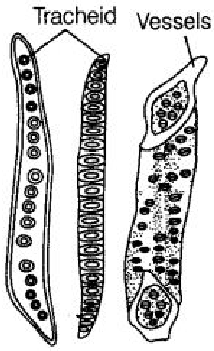


Fig. 6.6 Xylem

c. Xylem Fibres The sclerenchymatous fibres associated with the xylem are called xylem fibres. These fibres have lignified cell walls. The thickness of the walls varies considerably, but these are usually thicker than the walls of the tracheids in the same wood. These are found in both primary and secondary xylem. The xylem fibres provide mechanical strength.
d. Xylem Parenchyma The parenchyma cells associated with the xylem form xylem parenchyma. These cells form the only living component of the xylem. Xylem parenchyma stores food in the form of starch.
These cells assist direcdy or indirecdy in the conduction of water upward through the vessels and tracheids.
The xylem parenchyma can be sub-divided into two types Primary Xylem The xylem differentiating in the primary plant body is the primary xylem. The primary source of this xylem is the procambium. The primary xylem is of two types, i.e., protoxylem and metaxylem.
The first formed primary xylem elements are called protoxylem.The latter formed primary xylem is called metaxylem.
In stems, the protoxylem lies towards the centre (pith) and the metaxylem lies towards the periphery of the organ. This type of primary xylem is called endarch.

In roots, the protoxylem lies towards periphery and metaxylem lies towards the centre. Such arrangement of primary xylem is called exarch.
Secondary Xylem is composed of tracheary elements, rays, fibres and interspersed axial parenchyma cells. The cell formed toward inside of cambia are called secondary xylem or wood. The primary function of secondary xylem is to provide mechanical support to plants.

ii. Phloem

Phloem (Gk. Phbis—bark) is a food conducting complex permanent tissue. The term 'phloem' was coined by Nageli (1958). In angiosperms, it is also called bast. In gymnosperms, albuminous cells and sieve cells are present. The first formed primary phloem consists of narrow sieve tubes called protophloem and the latter formed phloem has bigger sieve tubes called metaphloem.

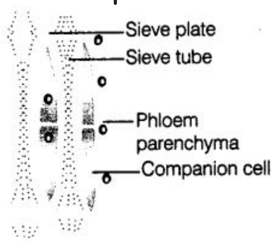


Fig. 6.7 Phloem

It consists of four types of cellular components,

(a) Sieve Elements The sieve tube elements are long, tube-like structures arranged longitudinally and are associated with the companion cells. Their end walls are perforated in a sieve-like manner to form the sieve plates. A mature sieve element possesses a peripheral cytoplasm and a large vacuole, but lacks a nucleus, Golgi body and most cytosol.

Sieve elements are of following two types

• Sieve cell It is a special kind of cell which posses sieve areas in its lateral walls. There is no specialised plate in it. Sieve cells are usually found in pteridophytes and gymnosperms.

• Sieve tube members In this type, the sieve areas are localised on its end walls. Sieve tube members are placed one above the other forming a continuations tube called sieve tube. The end walls are perforated (sieve pores) like a sieve. These are found in angiosperms.

The uniqueness of the sieve tube is that although without nucleus, it is living and the nucleus of the companion cell controls its functions.
The main function of sieve element is trans¬location of organic solutes. The callose (a plant polysaccharide) is present in the perforations in the sieve plates.

It is soluble and disappears when the solute is dilute so that the solute can pass from one cell to another cell through the pores. Callose reappears and sometimes closes the pores when solute is less dilute, thus stopping the movement.

(b) Companion Cells These are specialised parenchymatous cells, which are closely associated with the sieve tube elements. Usually, a single companion cell is found associated with a sieve tube member.

The cytoplasm of the sieve tube element and companion cells are connected by thin cytoplasmic strands called plasmodesmata, passing through the pit membranes in their walls. Companion cells are absent in the phloem of pteridophytes and gymnosperms. They have albuminous cells.

The companion cells In association with phloem parenchyma play an important role in the maintenance of a pressure gradient in sieve tubes. They form a link between sieve tube cells and other cells and regulate the passage of materials.

(c) Phloem Parenchyma The phloem parenchyma is made up of elongated, tapering cylindrical cells which have dense cytoplasm and nucleus. The cell wall is composed of cellulose and has pits though the plasmodesmatal connections, which exist between the cells.

They store food materials and other substances like resins, latex and mucilage. The phloem parenchyma is absent in most of the monocotyledons.

(d) Phloem Fibres The phloem fibres (bast fibres) are made up of sclerenchymatous cells. These are generally absent in the primary phloem but are found in secondary phloem. The cell wall of phloem fibres is quite thick. At maturity, these fibres lose their protoplasm and become dead. The phloem fibres of jute, flax and hemp have important economic uses.

The Tissue System

The tissues also vary, depending upon their location in the plant body. Their structure and function would also be dependent on location. Thus, on the basis of their structure and location, there are three types of tissue system, i.e., epidermal tissue system, ground or fundamental tissue system and vascular or conducting tissue system.

1. Epidermal Tissue System

The epidermal tissue system forms the outermost covering of the whole plant body. Its various components are epidermal cells, stomata and the epidermal appendages, i.e., trichomes and emergences.

Epidermis The epidermis (Gr. Epi-upon\ derma -skin) is the outermost layer of the primary plant body. The epidermal cells vary in shape and size and are compactly arranged to form a continuous layer. This layer is interrupted by stomata. Sometimes they are separated by intercellular spaces. It is usually single-layered but is also multilayered in the aerial roots of orchids and leaves of Nerium and Ficus elastica.

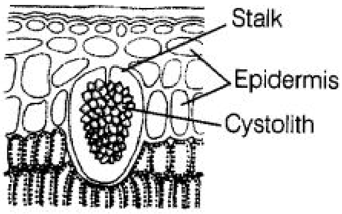


Fig. 6.8 Epidermis with a layer of cuticle and multiple epidermis

The cells are parenchymatous and living. Each cells has a large central vacuole and a peripheral thin cytoplasm. It is thicker in xerophytic plants. In roots the. outermost layer called epiblema, has tubular, unicellular, projections called root hair. The other substances deposited on cuticle surface may be oil, resin, silicon and salts (calcium oxalate or calcium carbonate).

Stomata The stomata (sing, stoma) are openings in the epidermis of most of the aerial parts of the plants, especially the leaves. Each stomata is composed of two bean-shaped cells called as guard cells, which enclose stomatal pore. The guard cells are generally much smaller in size as compared to other epidermal cells. They are sensitive to even a small change in turgor pressure. The dimension of stomatal pore varies from species to species but it measures about 20 Jim long and about 10-20 p.m wide when fully open.

In some species, the guard cells are surrounded by subsidiary cells or accessory cells which differ morphologically from the other epidermal cells. The guard cell walls have special elastic properties. The adjoining cell walls of two guard cells around pore are free and not attached with each other.

These properties help them to stretch laterally during stomatal opening. The stomatal aperture, guard cells and the surrounding subsidiary cells are together called stomatal apparatus.

In most monocots, the guard cells are dumb bell-shaped. The stomata are mostly found on the upper epidermis of the leaves. In some hydrophytes, the stomata occur on the upper surface to avoid water contact.

Based on their distribution, stomata are of following types

(a) Apple Type Present on the under side of a leaf, e.g., Apple, mulberry.

(b) Oat Type Stomata are almost equal on the two surfaces, e.g, Maize, oat.

(c) Potato Type These are more on the under surface, e.g, Cabbage, potato, bean.

(d) Water lily Type These stomata are more on the upper surface, e.g., Many aquatic plants.

(e) Potamogeton Type Stomata vestigial or absent, e.g, Potamogeton.

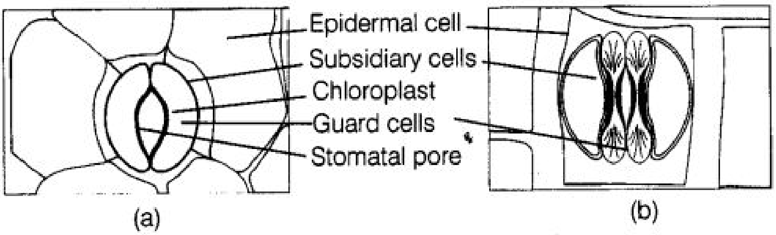


Fig. 6.9 Diagrammatic representation (a) Stomata with bean-shaped guard cells (b) Stomata with dumb-bell shaped guard cell

Epidermal Appendages (Outgrowths)

The epidermis of most plants often bear outgrowth known as epidermal appendages or epidermal outgrowths. They are of following two types

(a) Trichomes The epidermal hairs present on the stem are called trichomes. These are epidermal outgrowths present temporarily or permanently on almost all plant parts. The trichomes can be further divided as hair, scales, colleters and water vesicles or bladders.

(b) Emergences (Prickles) They are multicellular, stiff and sharp epidermal outgrowths containing some inner tissues. They protect the pliant against excessive loss of water and grazing. They also helps in climbing in some plants, e.g., Rose.

Epidermal tissue system serves the following important functions

(a) It provides a protective covering all over the plant parts.

(b) It helps in gas exchange through stomata and lenticles present on the surface.

(c) The presence of cuticle helps in the reduction of evaporation of water (epidermis).

(d) The glandular trichomes excrete various useful plant products for the plant function.

(e) In some monocot leaves, the bulliform cells help in the rolling and unrolling of leaves. This property helps to reduce transpiration in xerophytic plants.

2. Ground Tissue System

All tissues, except epidermis and vascular bundles constitute the ground tissue system. It mainly forms the bulk of the plant body. It's various components are hypodermis, cortex, endodermis, pericycle, medullary rays and pith.

i. **Hypodermis** This is the region situated just below the epidermis and as an outer region of cortex. It contains of one, two or few continuous or discontinuous layers of collenchyma (in dicots) or sclerenchyma (in monocots). It is protective and mechanical in function.

ii. **Cortex** The cortex lies between epidermis and endodermis consisting of parenchyma, collenchyma and sclerenchyma. The cortex is distinct in dicotyledons

but not in monocotyledons. The cells of cortex contain starch grains, oil, tannins and crystals. Sometimes, cortical cells may contain chloroplasts and are called chlorenchyma.
In hydrophytes, the cortex may be aerenchymatous (Spongy tissue with large air spaces found between the cells of the stems and leaves of aquative plants). The special types of cells like sclereids, resin ducts, oil glands laticifers are found in this region. The cortex helps in performing vital functions, such as storage, etc.
iii. Endodermis This is the innermost layer of the cortex. It is single-layered, barrel-shaped and arranged without intercellular spaces. The cells are parenchymatous. The presence of bands of suberin on the radial and transverse wall is the characteristic feature. These bands are called casparian strips. The endodermal cells of roots usually have thick, radial and inner tangential walls. These thick-walled cells form a continuous ring which is interrupted at certain places by passage cells, which are thin-walled and usually present opposite to the protoxylem region.
A well-developed endodermis is present in all types of roots, aerial stems of woody dicotyledons and gymnosperms with characteristic casparian thickenings.
The endodermis helps to control the movement of water and air between the cortex and xylem. It also helps to maintain the root pressure and conducts water to the protoxylem.

iv. Pericycle It is made up of a single layer or many layers of cells present between endodermis and vascular tissue. In roots, pericycle comprises cells of parenchyma. The pericycle is absent in roots and stems of some aquatic plants.
v. Medullary Rays The-medullary rays are non-vascular areas which occur between vascular bundles in dicot stems for lateral conduction. These are made up of parenchyma cells. These originate from the apical meristem. They serve the function of lateral transport.
vi. Pith The central portion of root and stem is occupied by pith. It contains parenchymatous cells and also sclerenchymatous cells laticifers, medullary vascular bundles, in some cases. In leaves, the ground tissue is parenchymatous and possesses chloroplast.
It performs the function of photosynthesis. The main function of pith is storage of water and food materials.
vii. Ground Tissue of Leaves In leaves the ground tissue of petiole is made up of parenchymatous cells with distinct intercellular spaces. In the lamina, the bulk of ground tissue is called mesophyll, which is usually differentiated into palisade and spongy parenchyma.

These cells are thin-walled and possess chloroplasts. The main function of mesophyll is in photosynthesis.

3. Vascular Tissue System

A vascular bundle is a strand of conducting tissue, which is generally composed of xylem and phloem in monocots and xylem, phloem and cambium in dicots.

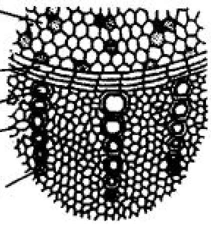


Fig. 6.10 Parts of a vascular bundies

These tissues originate from the procambium and apical meristems. The arrangement of xylem and phloem is the characteristic to particular plant organs. However, a few exception are also there.

On the basis of arrangement of xylem and phloem in the vascular bundles, there are three types of bundles, i.e., radial, conjoint and concentric.

i.Radial The xylem and phloem alternate with each other separated by parenchymatous cells. This types of vascular bundles are called radial and is found mainly in roots.

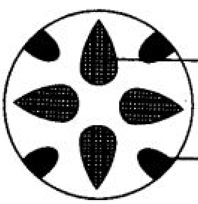


Fig. 6.11 Radial

ii. Conjoint The xylem and phloem are present together in the same bundle on the same radius. Conjoint bundles are of two types, i.e., collateral and bicollateral.

(a) Collateral The xylem and phloem lie together on the same radius. The xylem lies inwards and the phloem outwards.

They are of two types

In a dicot stem, the cambium is found to be present in between the xylem and phloem, such bundles are called open, e.g., Helianthus (sunflower).

When the cambium is absent, the vascular bundle is called as a closed bundle, e.g., Zea mays (maize).

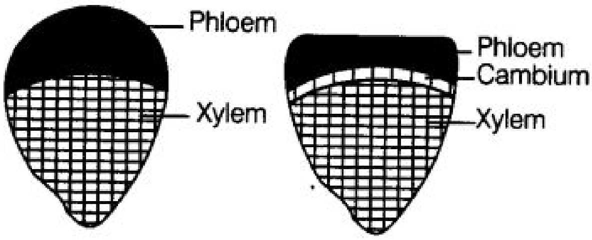


Fig. 6.12 Conjoint (a) Closed (b) Open

(b) Bicollateral This is the conjoint vascular bundle with two groups or patches of phloem, one on each side of the centrally located xylem. The various components are arranged in sequence of outer phloem, outer cambium, xylem, inner cambium and inner phloem. Such bundles are commonly found in the members of Cucurbitaceae. Such bundles are always open.

iii. Concentric A vascular bundle in which one tissue is completely surrounded by the other is called concentric. The concentric bundles are of two types, i.e., amphibasal (phloem lies in the centre and remains completely surrounded by xylem) and amphicribal (xylem lies in the centre and remains completely surrounded by phloem).

2. Anatomy of Dicotyledonous and Monocotyledonous Plants

The tissue organisation of roots, stems and leaves can be studied better and conveniently by the transverse sections of the mature zones of these organs.

I. Dicotyledonous Root

The primary internal structure of dicot root can be studied from the Transverse Section (TS) of a young root of sunflower, pea or gram. The primary root is the one which has only primary permanent tissues that are formed from vegetative shoot apex. Secondary tissues are absent.

The following structures can be seen from periphery towards the centre

1. Epiblema

It forms the outermost layer in young root. It is equivalent to epidermis of stem. The stomata and cuticle are not present in it. The cells are thin-walled and tubular. Some of the epiblema cells are prolonged to form thin-walled tubular structures called root hairs.

The cells which produce root hair are called root hair cells or trichoblasts. Due to the presence of root hairs, epiblema is also called piliferous layer (Pilus – hair; ferre – to carry) and rhizodertnis (Rhiza – root; derma – skin).

Root hairs having pectose layer on the outside, this is to help them to pass into the soil spaces for absorption of water and mineral salts. The active life span of root hairs is up to 7 days and die off in older parts of the root. The cell of older epiblema shrivel afterwards and become cutinised and suberised.

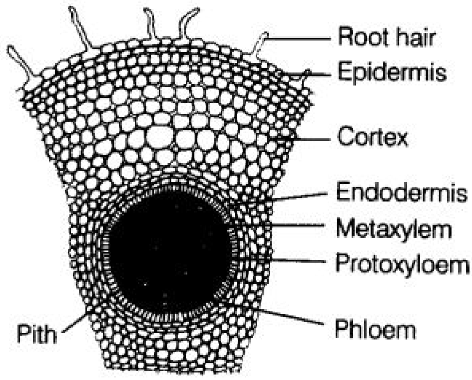


Fig. 6.13 TS of a dicot root (primary)

2. Cortex

It lies beneath the epiblema. It consists of several layers of thin-walled parenchymatous cells with conspicuous intercellular spaces. The cells of cortex store fipod. It also conducts water from the ebiblema to the inner tissues.

3. Endodermis

The innermost layer of the cortex is endodermis. It comprises of a single layer of barrel-shaped cells without any intercellular spaces. The endodermal cells are living and are rich in starch grains.

They have characteristic bands of thickenings along their radial and tangential walls. These are called casparian bands or casparian strips.

The casparian strips are made up of suberin and lignin. These strips prevent plasmolysis of endodermal cells and do not allow wall to wall movement of substances, between cortex and pericycle.

The cells of endodermis lying opposite to the protoxylem are thin-walled to permit free passage of water and minerals from cortex into the xylem. These are called passage cells.

4. Stele

All tissues on the innerside of the endodermis such as pericycle, vascular strand and pith constitute the stele.

i. Pericycle The next to endodermis lies a layer of thick-walled parenchymatous cells referred to as pericycle. The initiation of lateral roots and vascular cambium during the secondary growth takes place in these cells.

ii. Vascular Strand The vascular strand consists of separate bundles of xylem and phloem arranged alternately inner to the pericycle. Hence, the xylem and phloem bundles are equal in number and lie on different radii. Such vascular bundles are called radial bundles.

On the basis of number of xylem bundles, the root may be diarch (with two xylem bundles), triarch, tetarch, pentarch and polyarch (with more than five xylem bundles).
When the protoxylem is towards the periphery and the later formed xylem (metaxylem) is towards the centre of the root. This kind of xylem condition is called exarch and is characteristic of root.
The phloem and xylem bundles are separated from each other by one or more layers of small thin-walled cells called conjuctive tissue.
Later, it becomes meristematic and forms vascular cambium. The phloem tissues conducts organic food from leaf to the other parts of the plant. Secondary, growth occurs in dicot roots.
iii. Pith It is generally absent in dicot roots. If present, it is small. It consists of parenchyma cells that store food and waste products.
Features for Identification of Dicotyledonous Root
Dicotyledonous root can be easily identified with the following features
(i) Presence of root hairs.
(ii) Endodermis with casparian strips.
(iii) Absence of pith.
(iv) Radial bundles less than eight.
(v) Presence of exarch xylem.

II. Mononocotyledonous Root
This can be inferred from the following structures given below
1. Epiblema
It is the outermost, thin-walled, compactly arranged layer of cells. Some of the cells give rise to root hair. The root hair are unicellular and lie in contact with soil water. Both epiblema and root hair are devoid of cuticle. These helps in absorption of water and minerals. In older parts the epiblema is shed or impervious.
2. Cortex
It is a broad zone of parenchyma cells. The cells are thin-walled and enclose intercellular spaces. They normally store food. The cortex provides for radial movement of water and minerals from epiblema to the root interior.

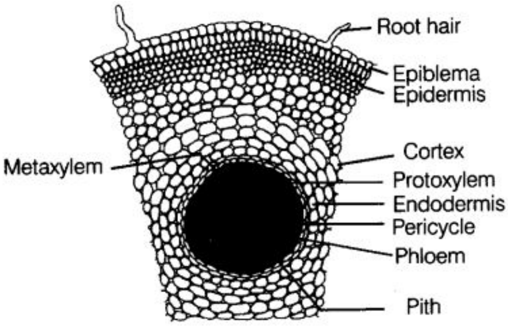


Fig. 6.14 TS of monocot root

3. Endodermis

It is single-layered and made up of barrel-shaped cells which do not enclose intercellular spaces. The young endodermal cells possess an internal strip of suberin and lignin, which is known as casparian strip. Endodermal cells lying opposite the protoxylem groups however, remain in the primary stage with usual casparian strip.

These unthickened cells are called passage or transfusion cells. These cells helps in conduction of fluids and minerals from cortex into the xylem.

4. Stele

All tissues inside the endodermis, i.e., pericycle, vascular bundles and pith form the stele.

i. Pericycle It forms the outer boundary of stele. Pericycle may be uniseriate (single layered) or multiseriate (multilayered).

The pericycle does not form cambium. It only produces lateral roots. The pericycle is composed of thin-walled parenchymatous cells in a young root. Later, it becomes thick-walled in many monocot roots.

ii. Vascular strand Vascular strand is in the form of several alternate and radial xylem and phloem bundles. The vascular bundles are arranged in the form of a ring around a central pith.

The xylem bundles are exarch, i.e., protoxylem lies towards the outside while, the metaxylem faces inwards. Due to the pressure of numerous xylem bundles and exarch condition, the xylem of monocot root is polyarch.

Protoxylem vessels are narrow while, the metaxylem vessels are the broad. Xylem provides mechanical strength and helps in conduction of water and mineral salts.

Phloem and xylem are separated from each other by means of a narrow strip of conjuctive tissue. The phloem cells stored food, if parenchymatous. They provide mechanical strength on becoming sclerified. They are involved in the formation of cambium.

iii. Pith It is large and well-developed. It is large and made up of parenchymatous cells with intercellular spaces. These cells contain starch.

Features for Identification of Monocotyledonous Root

Monocotyledonous root can be easily identified with the following features

(i) Presence of root hairs.

(ii) Endodermis with passage cells.

(iii) Presence of pith.

(iv) Radial bundles more than eight.

(v) Xylem exarch.

(vi) Presence of an exodermis.

Differences between Dicot Root and Monocot Root

Dicot Root	Monocot Root
The cortex is simple homogeneous and made up of parenchymatous cells.	Cortex is well-developed. It develops from one or more layers of thick-walled cells towards outside, called exodermis. Rest of the cells are parenchymatous.
The endodermis is prominent with casparian thickenings.	Endodermis is more prominent showing casparian thickenings.
Secondary growth occurs.	No secondary growth occurs (except in some plants).
Conjunctive tissue is parenchymatous.	Conjuctive tissue around metaxylem vessels is sclerenchymatous.
Pith is very small or absent.	Pith is large.

ysboiviedonous Stem

The transverse section (TS) of a typical young dicotyledonous stem shows the following areas

1. Epidermis

The outermost protective layer of the stem is called epidermis. It is covered with a thin-layer of cuticle and may bear trichomes and a few stomata. The cuticle protects the tissues from injury as well as diseases from the entry of fungal spores and bacteria. It also helps to prevent loss of water.

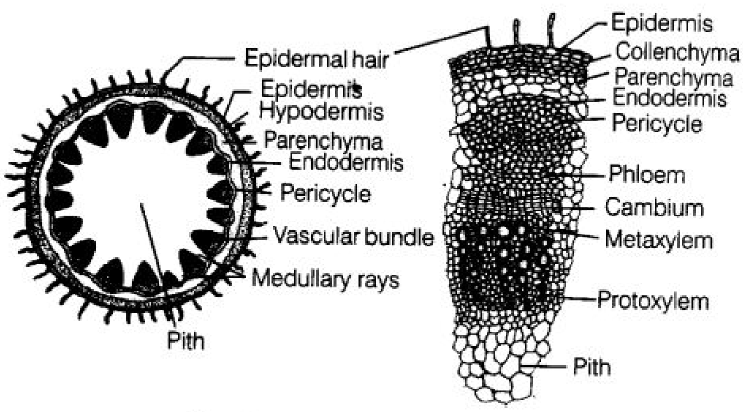


Fig. 6.15 TS of a dicot stem

2.Cortex

This layer lies just below the epidermis and extends till endodermis. Its various parts are hypodermis, general cortex and endodermis.
Hypodermis It is just below the epidermis consisting of collenchymatous cells. The cells contain chloroplasts. It provides mechanical strength to the stem.
General Cortex It is located just below the hypodermis and consists of a few layers of parenchymatous cells. These cells are thin-walled and may contain chloroplasts.
Endodermis It lies just beneath the general cortex in the form of single layer of barrel-shaped cells surrounding the stele. It is the innermost layer of cortex. In sunflower, it contains starch, v hence is called starch sheath.

3. Pericycle

It exists between the endodermis and the vascular bundles. The cells are sclerenchymatous with lignified cell walls and a few parenchymatous cells dispersed in between. Each patch is associated with phloem of the vascular bundle and is called the hard bast.

4. Vascular Strand

The vascular strand consists of many vascular bundles, arranged in the form of a ring around a central pith and inner to pericycle.
Each vascular bundle consists of phloem (on the outside), xylem (towards the Inner side) with a strip of cambium, between the two.
The vascular bundles are thus, conjoint (i.e., consists of both xylem and phloem), collateral (i.e., phloem and xylem are on the same radius) and open (i.e., a strip of cambium present between the two).

5. Medullary or Pith Rays

These are non-vascular areas present in between the vascular bundles. The medullary rays connect pith with pericycle and cortex. Cells are larger than those of cortex. The medullary rays take part in radial conduction of materials, i.e., food, water, gases, etc.

6. Pith or Medulla

It consists of the central part of the stem. It consists of rounded, oval or polygonal parenchymatous cells. Intercellular spaces are absent. The cells store food materials and waste products.
Features for Identification of Dicotyledonous Stem
Dicotyledonous stem can be easily identified with the following features
(i) Occurrence of multicellular hair over epidermis.
(ii) Collenchymatous hypodermis.

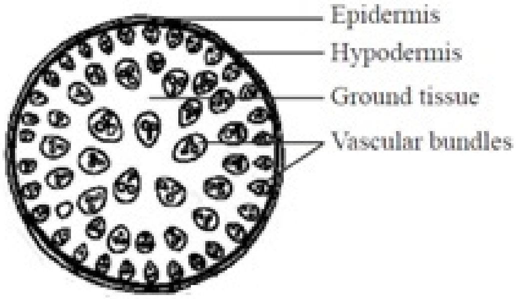
(iii) Presence of bundle caps or sclerenchymatous pericycle over vascular bundles.
(iv) Endarch xylem.

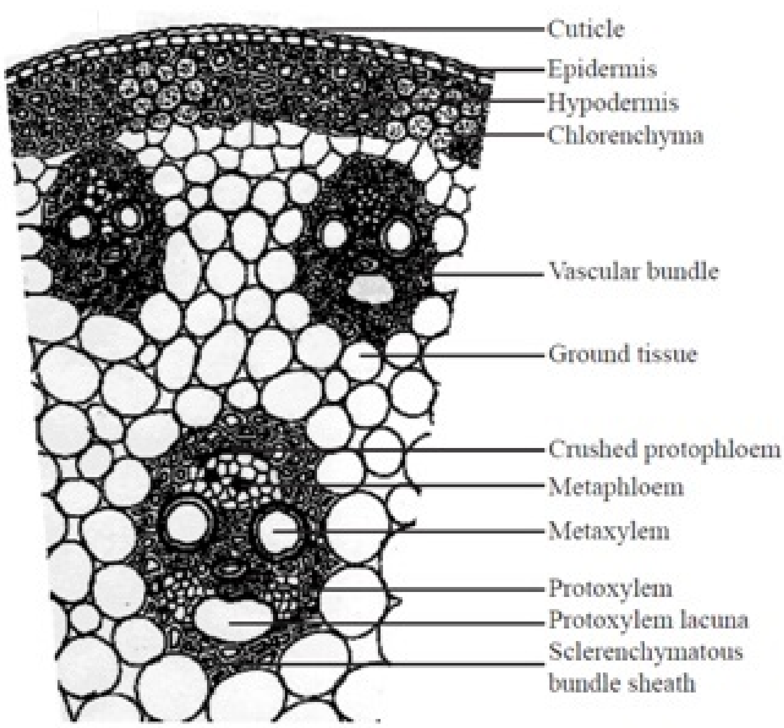
lyionocqtyledonous Stem

The monocot stem possesses only primary structure. The different monocot stem from outside towards inside are consists of epidermis, hypodermis, ground tissue and vascular system.

1. Epidermis

It is single layered, having stomata in it. The cells have a thick cuticle layer on the outside.





2. Hypodermis

It is 2-3 layered having lignified. sclerenchymatous cells present just below the epidermis.

3. Ground Tissue
It fills the whole interior of the stem containing parenchymatous cells. A number of vascular bundles are scattered in it.
4. Vascular System
Each vascular bundle in vascular strand is surrounded by a sheath of sclerenchyma known as bundle sheath cells. The vascular bundles possesses both phloem and xylem so, these are conjoint type.
The bundles are endarch with the protoxylem and metaxylem are arranged in the form. The divergent ends are occupied by two pitted vessels and convergent end by two smaller spiral vessels lying radially in the centre. A water containing cavity called lysigenous cavity is present in association with the protoxylem.
It is formed by the breakdown of inner protoxylem vessels and parenchyma during the earlier stages of growth. The cavity is absent or reduced in the smaller vascular bundles that occur in contact with sclerenchymatous hypodermis.
Features for Identification of Monocotyledonous Stem
Monocotyledonous stem can he easily identified with the following features
(i) Sclerenchymatous hypodermis present.
(ii) Undifferentiated ground tissue.
(iii) Vascular bundles scattered throughout ground tissue.
(iv) Vascular bundles are conjoint, collateral and closed.
(v) Protoxylem cavity present.
Dicotyledonous (Dorsiventral) Leaf
The dorsiventral leaves are generally horizontal and sunlight falls on their upper surface (ventral surface or adaxial surface).
The vertical section of a dorsiventral leaf through the lamina shows the following main parts
1. Epidermis
The epidermis covers both the upper (adaxial) and the lower (abaxial) surfaces of the leaf.
Upper Epidermis It is the uppermost, single layered, made up of parenchymatous cell, but sometimes, multilayered, e.g, Ficus, Piper, Nerium, Begonia. Also there is cuticle which covers the upper epidermis.
The outgrowths called papillae {e.g., Gladiolus) are sometimes present in epidermal cells. The stomata are usually less present in the upper surface. Chloroplasts are not present in this layer.
ii. Lower Epidermis The stomata and chloroplasts are more in number in the lower epidermis. There is sub-stomatal cavities present below the stomata for the gaseous exchange.

2. Mesophyll

It is differentiated in two parts in dorsiventral leaves, i.e., upper palisade and lower spongy parenchyma. The palisade cells contain abundant chloroplasts, Hence, they are the major seat of photosynthetic activity.

The spongy parenchyma lies below the palisade parenchyma and above the lower epidermis. This spongy parenchyma cells contain several chloroplasts but less than the number present in palisade cells.

Vascular System

The vascular bundles are conjoint, collateral, endarch and closed. Each bundle is surrounded by a bundle sheath of parenchymatous cells. The xylem is present towards upper epidermis (adaxial surface) and phloem towards lower epidermis (abaxial surface).

The xylem consists of vessels or trachae, tracheids, xylem parenchyma and xylem fibres. It is meant for the conduction of water and minerals.

The phloem is made up of sieve tubes, companion cells, phloem parenchyma and phloem fibres. Each vascular bundle is surrounded by a layer of thick-walled cells arranged compactly and known as bundle sheath cell (in C4-plants only).

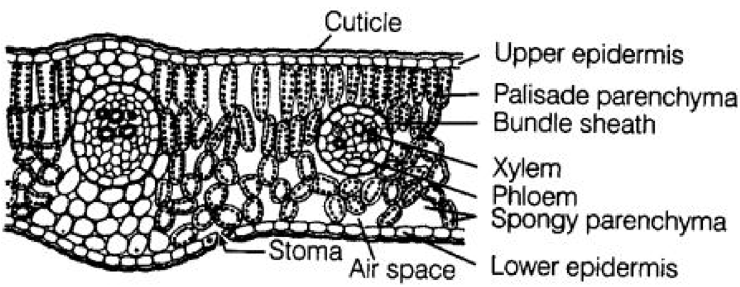


Fig. 6.17 TS of dicot leaf

The vascular bundles can be seen in the veins and the midrib. The size of vascular bundles vary according to the size of the veins. The veins vary in thickness in the reticulate venation.

Mesophyll is absent in the region of midrib and other larger veins. Collenchyma or sclerenchyma occur towards the two epidermal layers for providing mechanical strength. The centre contains a number of vascular bundles, which are embedded in a parenchymatous ground tissue.

Features for Identification of Dicotyledonous Leaf

Dicotyledonous leaf can be easily identified with the following features

(i) Bifacial flattered with stomata mostly on upper surface.

(ii) Mesophyll differentiated into palisade and spongy parenchyma. .

(iii) Vascular bundles with colourless bundle sheath (in C4-plants).

(iv) Vascular bundle with xylem towards upper side and phloem towards lower side.

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(iii) Vascular bundles with colourless bundle sheath (in C4-plants).
(iv) Vascular bundle with xylem towards upper side and phloem towards lower side.

3. Vascular Bundle

A large number of vascular bundles are present, some of them are small and some are big. Each vascular bundle is surrounded by a bundle sheath of parenchymatous cells. Above and below the larger bundle, the patches of sclerenchymatous cells are present.
The vascular bundles are conjoint, collateral, endarch and closed. In some grasses, these are surrounded by a distinct parenchymatous bundle sheath. The xylem is present towards the upper epidermis and phloem towards the lower epidermis. The xylem and phloem elements of monocot leaves are similar to those of dicot leaves.

4. Midrib

It is the widest part of monocot leaf. A shallow groove is present in the upper or adaxial surface, while a broad ridge is present on the abaxial surface.

Features for Identification of Monocotyledonous Leaf

Monocotyledonous leaf can be easily identified with the following features
(i) Presence of large sized bulliform cells on upper surface.
(ii) Undifferentiated mesophyll.
(iii) Presence of bundle sheath with chloroplasts.
(iv) Vascular bundle with xylem towards upper side and phloem towards lower side.
(v) Xylem vessels rounded.

Secondary Growth

The growth of the roots and stems in length with the help of apical meristem is called the primary growth. Apart from primary growth, most dicot plants exhibit the increase in girth. This increase is called secondary growth.

Secondary Growth in Dicot Stem

In a dicot plant, secondary growth in stem occurs both in the stele and in the cortex. The dicot stem, in its primary state of growth contains narrow layers of intrafascicular cambium in between the xylem and phloem.

The tissues involved in the secondary growth are the two lateral meristems, i.e., vascular cambium and cork cambium.

1. Vascular Cambium

The meristematic layer that is responsible for cutting off vascular tissues such as xylem and phloem is called vascular cambium. It is present in a patch of a single layer in young stem which later on develops into a complete ring.

Formation of Cambium Ring

The parenchyma cells of the primary medullary rays adjacent to the intrafascicular cambium undergo dedifferentiation and give rise to interfascicular cambium. This joins the intrafascicular cambium of either side to form a complete ring of meristem called the cambium ring.

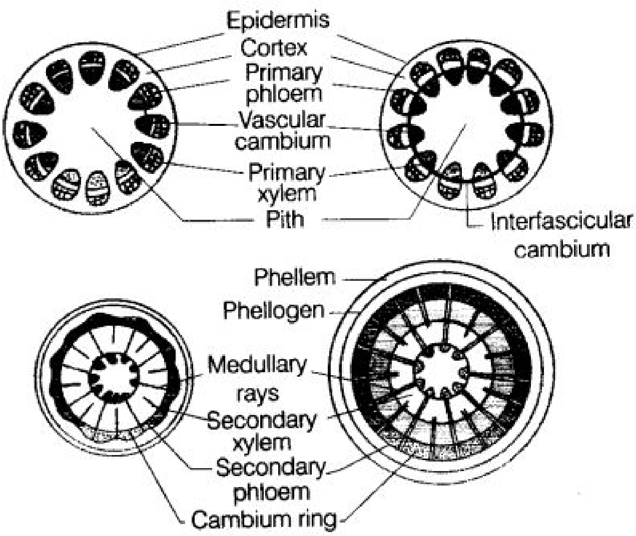


Fig. 6.19 Secondary growth in a dicot stem (diagrammatic)– stages in transverse views

Activity of Cambial Ring

The cambial ring becomes active and begins to form new cells, both towards and inner and the outer sides. The cambial ring is made up of two types of cells ray initials and fusiform initials. The cells added to the inner side of cambium ring by the division of the fusiform initials gradually become the elements of the secondary xylem. While, the cells added to the outer side of the cambium become elements of the secondary phloem. While, the cells added by the division of ray initials to the inside as well as outside become elements of the secondary medullary rays.

The cambium is generally more active on the inner side than the outer. As a result, the amount of secondary xylem produced is more than secondary phloem and soon forms a compact mass.
The primary and secondary phloems get gradually crushed due to the continued formation and accumulation of secondary xylem. The primary xylem however, remains more or less intact, in or around the centre. At some places, the cambium forms a narrow band of parenchyma, which passes through the secondary xylem and the secondary phloem in the radial direction. These are secondary medullary rays.

Formation of Annual Rings
In tropical areas, the growth of secondary xylem is continuous. In others, yearly growth is quite distinct and appears in the form of annual rings. The transition from spring wood to autumn wood is gradual. After autumn wood and before spring wood of next year, there is no growth.
Therefore, change over from autumn wood to spring wood is sudden. The light coloured spring wood and its next dark coloured autumn wood constitutes an annual ring or growth ring.
It represents the total secondary xylem or wood formed in one year. Hence, by counting the number of annual rings, the age of a plant can be determined. This is done with the help of an instrument called increment borer. Besides giving the age of the plant, the annual rings can also provide information of the climatic conditions prevailing in the past.
Spring Wood and Autumn Wood
The activity of cambium is under the control of many physiological and environmental factors. In temperate regions, the climatic conditions are variable through the year.
In springs, cambium is very active and produces a large number of xylary elements having vessels with wider cavities. The wood formed in this season is called spring wood or early wood.
In autumn, the cambium is less active and forms few xylary elements that have narrow vessles. Thus, the wood formed is called autumn wood or late wood.

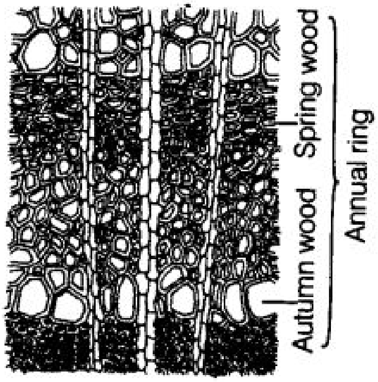


Fig. 6.20 Annual ring in a transverse section of dicotyledonous wood

In old trees, the considerable region of secondary xylem is dark brown due to the accumulation of organic materials like tannins, resins, nils, gums, aromatic substances and essential oils in the central or innermost layers of the stem. These substances make it hard, durable and resistant to the attacks of microorganisms and insects. This region comprises dead elements with highly lignified walls and is called heartwood.

The heartwood does not conduct water, but it gives mechanical support to the stem. The peripheral region of the secondary xylem, is lighter in colour and is known as the sapwood, which is involved in the conduction of water and minerals from root to leaf.

Cork Cambium

The stem continues to increase in girth due to the activity of vascular cambium. Due to this, the outer cortical and epidermis layers get broken and needs to be replaced to provide new protective cell layers. Therefore, another meristematic tissue called cork cambium or phellogen develops usually in the cortex region. Phellogen is a couple of layers thick. It is made of narrow, thin-walled and nearly rectangular cells. Phellogen cuts off cells on both sides. The outer cells differentiate into cork or phellem while the inner cells differentiate into secondary cortex or phelloderm.

The cork is impermeable to water due to suberin deposition in the cell wall. The cells of secondary cortex are parenchymatous. The phellogen, phellem and phelloderm are collectively known as periderm.

Bark

Bark is a non-technical term used to describe all tissues exterior to the vascular cambium, therefore including secondary phloem. The bark refers to a number of tissues, i.e., periderm and secondary phloem. The bark that is formed early in the season is called early or soft bark. Towards the end of the season, late or hard bark is formed.

Lenticels

At certain regions of stem, the phellogen cuts off closely arranged parenchymatous cells on the outer side instead of cork cells. These parenchymatous cells soon rupture the epidermis, forming a lens-shaped openings called lenticels. The lenticel are mosdy found in woody trees. The lenticels permit the exchange of gases between the outer atmosphere and the internal tissue of the stem.

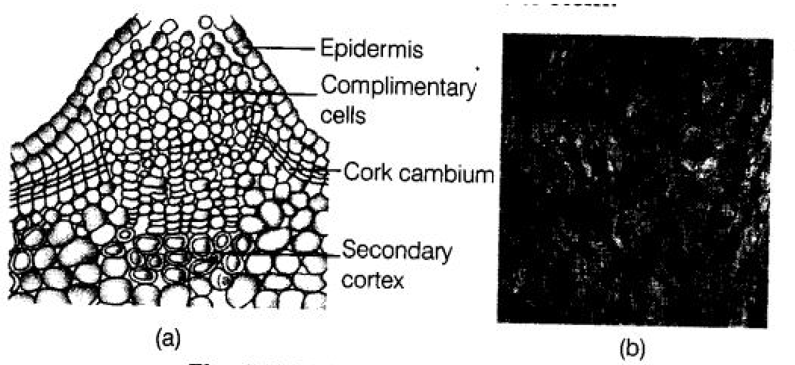


Fig. 6.21 (a) Lenticel and (b) Bark

Secondary Growth in Roots

The secondary growth in the root is the thickness due to the formation of secondary tissues by lateral meristems. With the exception of some annuals, most of the dicots and gymnosperms show secondary growth in their roots. It occurs by the production of two types of secondary tissues,
i.e., the secondary vascular tissues and periderm. These tissues are formed by meristems are vascular cambium and cork cambium, respectively.

Formation of Vascular Cambium

The conjunctive parenchyma cells, on the lateral sides of the phloem bundles as well as pericycle cells lying outside the protoxylem end becomes brick-shaped and meristematic. These develop into a wavy band of vascular cambium. The vascular cambium of the root is a secondary meristem. It continues to form secondary xylem on the inner side and secondary phloem on the outer side.
Secondary phloem consists of sieve tubes, companion cells, phloem parenchyma and phloem fibres. The secondary xylem contains elements like vessels, xylem parenchyma and xylem fibres.

Activity of Vascular Cambium

The vascular cambium derived from the pericycle gives rise to only ray cells. The formation of these ray cells is slower, than the formation of secondary vascular tissues. Due to this, the depressed parts of vascular cambium move outwardly and ultimately the cambium becomes circular.

Effect of Growth of Secondary Tissue
The primary phloem gets crushed due to the growth of secondary vascular tissues. The older secondary phloem is also partially destroyed as the new phloem becomes functional.
The primary and secondary xylems persist. Primary xylem is distinguishable by its : exarch nature and central position. As compared to the primary xylem, the vessels of the secondary xylem are broader and thinner. Annual rings are not very sharp. This is because the climate of the soil does not vary much during different seasons.
Formation of Cork Cambium

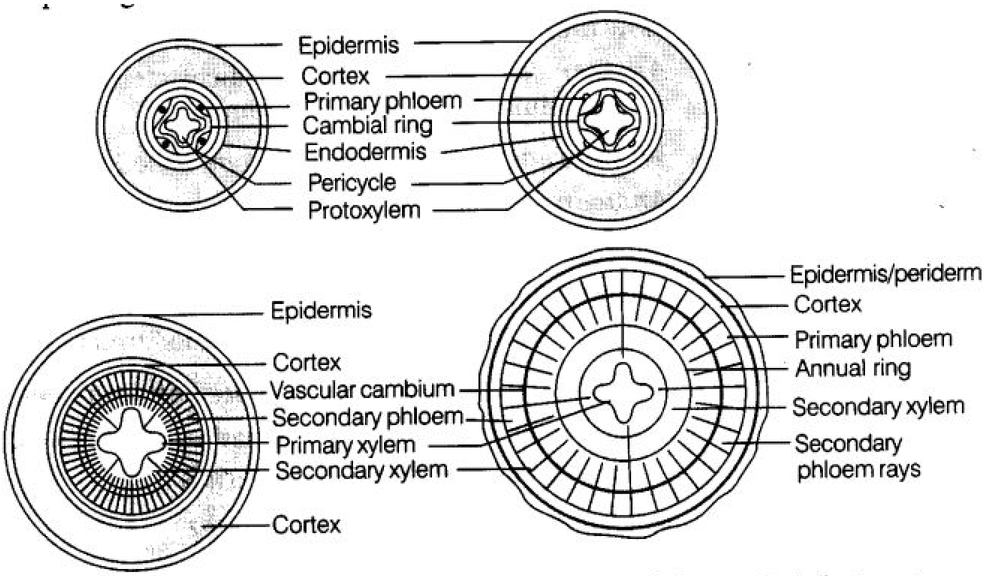
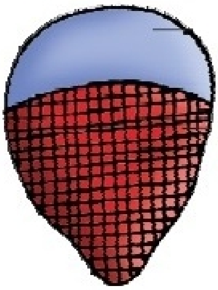


Fig. 6.22 Different stages of the secondary growth in a typical dicot root

Anatomy of Flowering Plants Class 11 MCQs Questions with Answers

Question 1.
Quiescent centre is present in the
(a) apical meristem
(b) shoot meristem
(c) lateral meristem
(d) root meristem
Answer
Answer: (d) root meristem

Question 2.
Closed vascular bundles lacks
(a) pith
(b) xylem
(c) cambium
(d) xylem vessels
Answer
Answer: (c) cambium
Explanation:



Picture of closed conjoint vascular bundles.

Question 3.
Which of the following is not a feature of spring wood?
(a) Color of the wood is light.
(b) Density is less.
(c) Cambium is active.
(d) Lesser number of xylary elements.
Answer
Answer: (d) Lesser number of xylary elements.
Explanation:
Spring season produces a wood which has large number of xylary elements having vessels with wider cavities.

Question 4.
In a monocot leaf
(a) bulliform cells are absent from the eqidermis
(b) veins from a network
(c) mesophyll is well differentiated into palisade and spongy parenchyma
(d) mesophyll is not differentiated into palisade and spongy parenchyma
Answer
Answer: (d) mesophyll is not differentiated into palisade and spongy parenchyma

Question 5.
A.T.S. of a young dicot root can be distinguished from that of a young dicot stem by the presence of
(a) radial arrangement of xylem and phloem
(b) collateral arrangement of xylem and phloem
(c) interfascicular cambium
(d) intrafascicular cambium
Answer
Answer: (a) radial arrangement of xylem and phloem

Question 6.
Fusifrom initial cells of cambium from
(a) vascular rays
(b) tracheary elements
(c) ray parenchyma
(d) phloem parenchyma
Answer
Answer: (b) tracheary elements

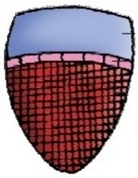
Question 7.
Callose deposition is found in
(a) tracheids
(b) companion cells
(c) sieve areas
(d) phloem parenchyma
Answer
Answer: (c) sieve areas

Question 8.
Stem develops from
(a) radicle
(b) cotyledon
(c) mesocarp
(d) plumule
Answer
Answer: (d) plumule
Explanation:
Stem develops from plumule.

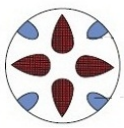
Question 9.
Stem grows in girth due to
(a) outer cortical
(b) epidermis
(c) vascular cambium
(d) phellogen
Answer
Answer: (c) vascular cambium
Explanation:
Stem increase in girth due to the activity of vascular cambium.
In this process, the outer cortical and epidermis layers gets broken.
This layer is replaced with new protective cell layer.

Question 10.
Which of the following is true about heartwood?
(a) They are dead but gives mechanical support to stem.
(b) They are light in color.
(c) They conduct water and minerals.
(d) 1 and 3
Answer
Answer: (a) They are dead but gives mechanical support to stem.
Explanation:
Heartwood is dead and have non-conducting elements.

Question 11.
Which picture shows conjoint closed vascular bundles?


(a)


(b)

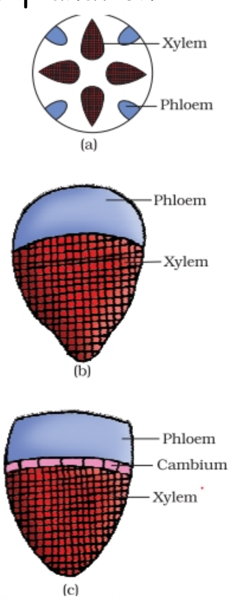

(c)

(d) None of these pictures shows conjoint closed vascular bundles.

Answer

Answer: (b)

Explanation:



Various types of vascular bundles :(a) radial (b) conjoint closed (c) conjoint open

Question 12.

Pith is very well developed in

(a) monocot root and monocot srem

(b) monocot root and dicot root

(c) dicot root and monocot stem

(d) monocot root and dicot stem

Answer

Answer: (d) monocot root and dicot stem

Question 13.
Which of the following helps in the curling of the leaf surface?
(a) Bulliform cells
(b) Xylem tissue
(c) Palisade parenchyma
(d) Bundle sheath cells
Answer
Answer: (a) Bulliform cells
Explanation:
In grasses, adaxial epidermal cells along the veins modify themselves into large, empty, colorless cells. These are called bulliform cells.
When there is water stress leaves curl themselves inward to minimise water loss.
When the cells have absorbed water and are turgid, the leaf surface is exposed.

Question 14.
Walls of sclerenchyma are
(a) rigid
(b) lignified
(c) pectinised
(d) suberised
Answer
Answer: (b) lignified

Question 15.
Fusifrom initial cells of cambium from
(a) vascular rays
(b) tracheary elements
(c) ray parenchyma
(d) phloem parenchyma
Answer
Answer: (b) tracheary elements

Question 16.
Closed vascular bundles lacks
(a) pith
(b) xylem

(c) cambium
(d) xylem vessels
Answer
Answer: (c) cambium

Question 17.
After the secondary growth, the oldest layer of secondary phloem in a dicot stem is located
(a) just outside the vascular cambium
(b) just inside the vascular cambium
(c) just inside the vascular phloem
(d) just outside the secondary xylem
Answer
Answer: (c) just inside the vascular phloem

Question 18.
The innermost layer of cortex which shows casparian thickenings in its cells is called as
(a) epidermis
(b) endodermis
(c) pericycle
(d) exodermis
Answer
Answer: (b) endodermis

Question 19.
Vessels differ from tracheids
(a) in being living
(b) in being derived from a single cell
(c) in that they consist of vertical row of cells with cross walls dissolved
(d) in coducting water and minerals
Answer
Answer: (c) in that they consist of vertical row of cells with cross walls dissolved

Question 20.
Endodermis cells are rich in
(a) cellulose
(b) starch grains

(c) fibers
(d) resins and wax
Answer
Answer: (b) starch grains
Explanation:
Endodermis cells are rich in starch grains.

Solutions For Class 11 Biology Anatomy of Flowering Plants

Solutions for Class 11 Biology Chapter 6 Anatomy of Flowering Plants:

Section Name	**Topic Name**
6	Anatomy of Flowering Plants
6.1	The Tissues
6.2	The Tissue System
6.3	Anatomy of Dicotyledonous and Monocotyledonous Plants
6.4	Secondary Growth
6.5	Summary

TEXTBOOK QUESTIONS SOLVED

1.State the location and function of different types of meristems.
Soln. Meristems are of three types on the basis of their location in plant body:
(i) Apical meristem: It is present at the apices of root and shoot and is responsible for increase in length.
(ii)Intercalary meristem: It is present at the bases of leaves above the nodes or below the nodes and is responsible for elongation of the organs.
(iii)Lateral meristem : It is present on lateral side and is responsible for increase in girth or diameter.

2.Cork cambium forms tissues that form the cork. Do you agree with this statement? Explain.
Soln. Yes, I agree with this statement. Cork cambium cuts off cells both on its outer side and inner side. The cells cut off on outer side form cork and cells cut

off on inner side form secondary cortex. The cells of cork are dead whereas those of secondary cortex are living.

3.Explain the process of secondary growth in the stems of woody angiosperms with the help of schematic diagrams. What is its significance?

Soln. Secondary growth is the formation of secondary tissues from lateral meristems. It is found in dicots only. It increases the diameter of the stem. Secondary tissues are formed by two types of lateral meristems, vascular cambium and cork cambium. Vascular cambium produces secondary vascular tissues while cork cambium forms periderm.The vascular bundles in dicot stem are conjoint, collateral, open and are arranged in a ring. The cambium present between xylem and phloem in vascular bundles is called fascicular or intrafascicular cambium. Besides this, some cells of medullary rays also become meristematic and this is called interfascicular cambium. Both these cambia collectively constitute complete ring of vascular cambium. This ring of vascular cambium divides periclinally to cut off cells both on inner side and outer side. The cells cuts off on outer side are secondary phloem and inner side are secondary xylem. Amount of secondary xylem cut off is more than secondary phloem and thus with the formation of secondary tissue, increase in girth or diameter occurs. The structure of secondary xylem and secondary phloem is similar to that of primary xylem and primary phloem. With the increase in secondary tissue, the primary xylem and primary phloem get crushed. The ray initials of vascular cambium ring divide by tangential divisions and add new cells. These new cells produced on both the sides of ray initials remain meristematic for sometime and then differentiate into parenchymatous cells of rays. The rays, produced by vascular cambium in between the secondary xylem and secondary phloem, are called secondary medullary rays. They are usually one to few layers in thickness and one to several layers in height. The medullary rays form the radial systejn responsible for radial conduction of solutes. They maintain connection between pith and cortex There is a marked difference in activity of cambium with change in season. In spring, the activity of cambium is more and hence the wood elements are larger in size with wide lumen. The activity of cambium is less during autumn and the wood elements are smaller in size with narrow lumen. Spring wood and autumn wood of a year constitute annual ring.
In order to increase in girth and prevent harm on the rupturing of the outer ground tissues due to the formation of secondary vascular tissues, dicot stems produce a cork cambium or phellogen in the outer cortical cells. Phellogen cells divide on both the outer side as well as the inner side to form secondary tissues. The secondary tissue formed on the inner side is called secondary cortex while the

tissue formed on outer side is called cork.

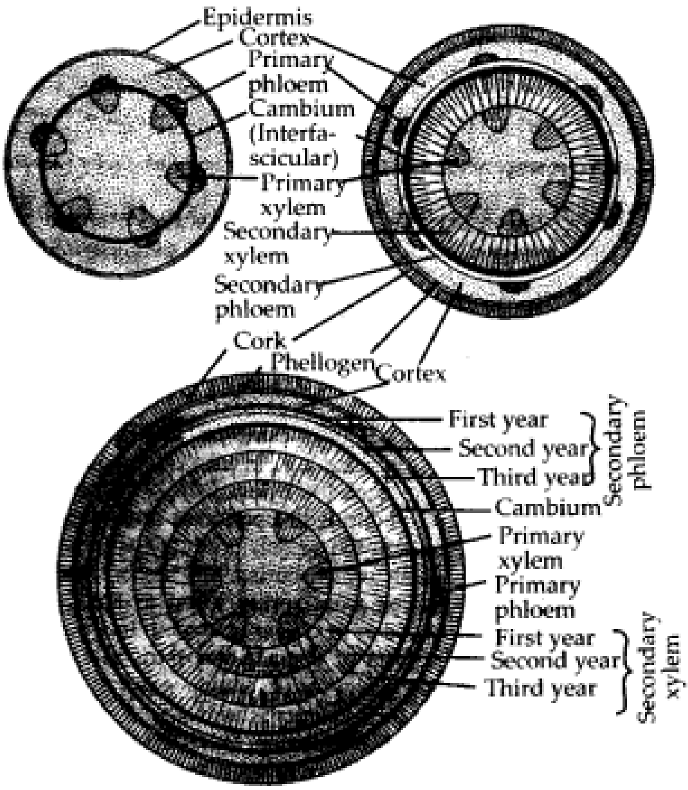


Fig.: Stages of secondary growth in a woody stem.

Significance of secondary growth is as follows:

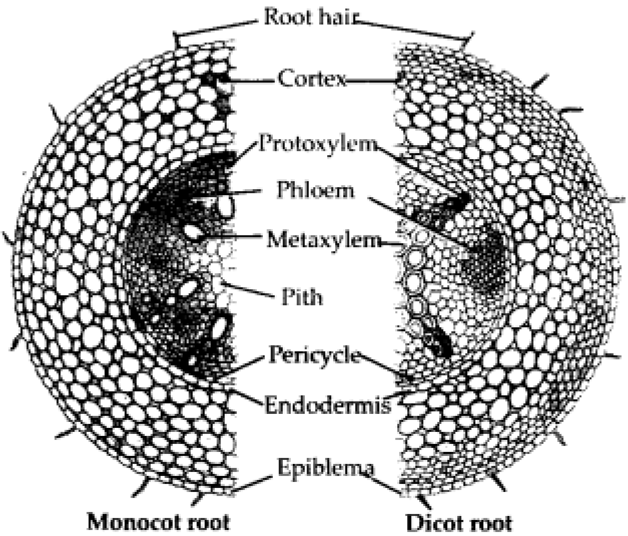
(i) It adds to the girth of the plant thus provides support to increasing weight of aerial parts due to growth.

(ii)It' produces a corky bark around the tree trunk that protects the interior from abrasion, heat, cold and infection.

(iii)It adds new vascular tissues for replacing old non-functioning one as well as for meeting increased demand for long distance transport of sap and organic nutrients.

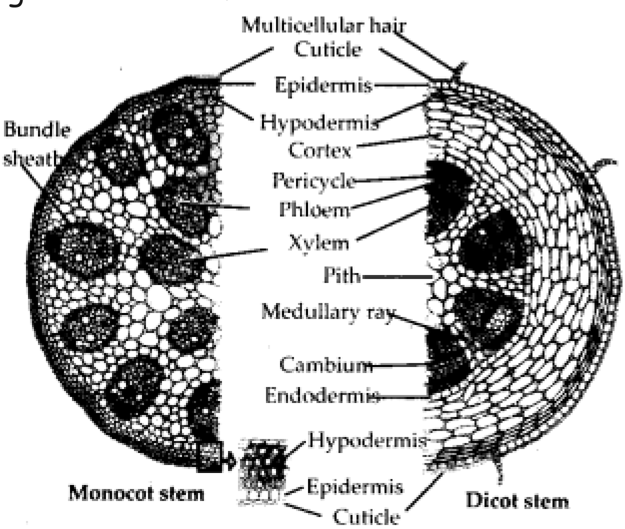
4.Draw illustrations to bring out the anatomical difference between
(a) Monocot root and dicot root
(b) Monocot stem and dicot stem

Soln.(a) Differences between monocot root and dicot root are illustrated in the following figure and table.



	Features	Monocot root	Dicot root
(i)	Cortex	Comparatively narrow.	Very wide.
(ii)	Endodermis	Less thickened and casparian strips are more prominent.	Later become highly thickened. Casparian strips are visible only in young root.
(iii)	Passage cells	Generally absent.	Generally occur opposite the protoxylem point.
(iv)	Pericycle	Produces lateral roots, cork cambium and part of the vascular cambium.	Produces lateral roots only.
(v)	Vascular bundles	2 to 5 or some times 8.	8 or more in number.
(vi)	Pith	Either absent or very small.	Well-developed.

(b) Differences between monocot and dicot stems are illustrated in the following figure and table.



	Features	Monocotyledonous stem	Dicotyledonous stem
(i)	Vascular bundles	(a) Scattered (b) Conjoint, collateral, closed (c) Bundle sheath usually present. (d) Phloem parenchyma absent. (e) Xylem vessels arranged either in Y or V shaped manner.	(a) Vascular bundles in ring (b) Conjoint, collateral or bicollateral and open. (c) Bundle sheath absent. (d) Phloem parenchyma present. (e) Not so.
(ii)	Pith (Medulla)	Absent	Made up of parenchymatous cells situated in the centre of stem.
(iii)	Ground tissue	Ground tissue is not differentiated into the cortex and pith	Differentiated into the cortex and pith.
(iv)	Hypodermis	Usually sclerenchymatous	Collenchymatous.
(v)	Endodermis	Absent	One layered, starchy sheath which is usually not well differentiated.
(vi)	Pericycle	Absent	Made up of one or more layers of parenchymatous and/or sclerenchymatous cells.
(vii)	Medullary rays	Absent	Found in between vascular bundles.

5.Cut a transverse section of young stem of a plant from your school garden and observe it under the microscope. How would you ascertain whether it is a monocot stem or a dicot stem ? Give reasons.

Soln. Vascular bundles in dicot stem are arranged in a ring whereas in monocot stem vascular bundles are scattered throughout the ground tissue. On the basis of arrangement of vascular bundles it can be ascertained
whether the young stem is dicot or monocot. Besides undifferentiated ground tissue, sclerenchymatous hypodermis, oval or circular vascular bundles with Y shaped xylem are other differentiating features of monocot stem.

6.The transverse section of a plant material shows the following anatomical features – (a) the vascular bundles are conjoint, scattered and surrounded by a sclerenchymatous bundle sheath, (b) phloem parenchyma is absent. What will you identify it as?

Soln. The plant material is identified as monocot stem.

7. Why are xylem and phloem called complex tissues?

Soln. A group of different types of cells which perform common function is called complex tissue. Xylem and phloem are called complex tissues as all cells that work as a unit for a common function have different structural organisation. Xylem has four types of cells-tracheids, vessels, xylem parenchyma and xylem fibres. Phloem consists of sieve tube elements, companion cells, phloem parenchyma and phloem fibres. Xylem is associated with conduction of water and minerals from roots to top of plants and phloem is responsible for transport of organic food.

8. What is stomatal apparatus? Explain the structure of stomata with a labelled diagram.

Soln. Stomata are structures present in the epidermis of leaves. Stomata regulate the process of transpiration and gaseous exchange. Each stoma is composed*of two bean shaped cells known as guard cells which enclose stomatal pore. The outer walls of guard cells (away from the stomatal pore) are thin and the inner walls (towards the stomatal pore) are highly thickened. The guard cells possess chloroplasts and regulate the opening and closing of stomata. Sometimes, a few epidermal cells, in the vicinity of the guard cells become specialised in their shape and size and are known as subsidiary cells. The stomatal aperture, guard cells and the surrounding subsidiary cells are together called stomatal apparatus.

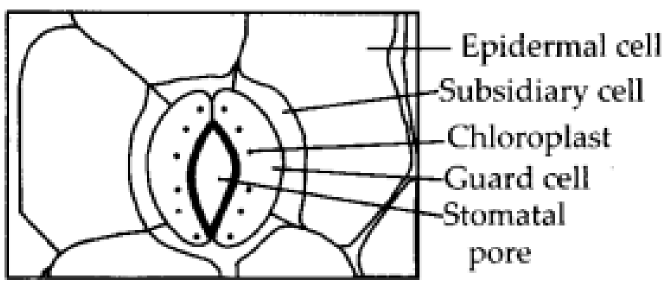


Fig.: Diagrammatic representation of stomatal apparatus

9. Name the three basic tissue systems in the flowering plants. Give the tissue names under each system.

Soln. The three basic tissue systems in flowering plants are epidermal tissue system, ground tissue system and vascular tissue system.
Epidermal tissue system comprises epidermal cells, stomata, trichomes and hairs.
Ground tissue system consists of cortex, endodermis, pericycle, pith and medullary rays, in the primary roots and stems. In¬leaves, the ground tissue consists of thin

walled chloroplast containing cells and is called mesophyll.
The vascular tissue system consists of complex tissues, the phloem and the xylem.

10.How is the study of plant anatomy useful to us?
Soln. Study of internal structures of plants is called plant anatomy. Study of plant anatomy is useful:
-for solving taxonomic problems.
-for knowing homology and analogy of various plant groups.
-to differentiate the superior and inferior, standard and substandard or specified and unspecified woods.
-in establishing purity and correct identity of plant parts in pharmacognosy (science connected with sources, characteristics and possible medicinal uses).
-in knowing the structural peculiarities of different groups of plants.

11 .What is periderm? How does periderm formation take place in the dicot stems?
Soln. phelloderm, phellogen and phellem together constitute the periderm. Periderm is protective in function.Dicot stems produce cork cambium or phellogen in the outer cortical cells. Phellogen cells divide on both the outer side as well as the inner side to form secondary tissues. The secondary tissue produced on the inner side of the phellogen is called secondary cortex or phelloderm. On the outer side phellogen produces cork or phellem.

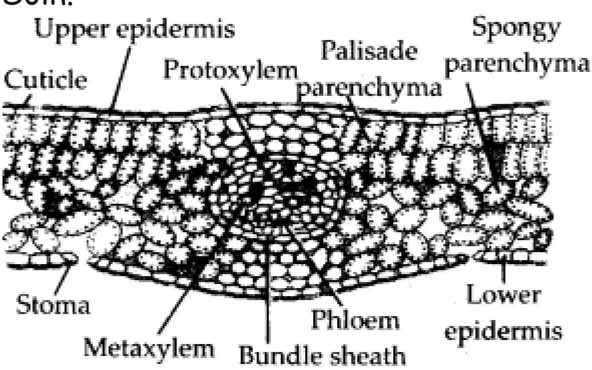
12.Describe the internal structure of a dorsiventral leaf with the help of labelled diagram.
Soln.


Fig.: T.S. of a dorsiventral leaf
Dorsiventral leaves are found in dicots. The important anatomical features of dorsiventral leaves are discussed below:
(a) Upper epidermis : This is generally outermost single layer made of

parenchymatous cells. The epidermal cells have sometimes outgrowths called papillae, e.g., in Gladiolus. The epidermal cells are devoid of chloroplast and stomata are absent on upper epidermis.

(b) Lower epidermis : It is just like upper epidermis but here stomata are present. Chloroplasts are absent in lower epidermis also, except the guard cells of stomata.

(c)Mesophyll: In between upper and lower epidermis mesophyll tissue is present which can be divided into two regions:

(i)Palisade parenchyma : These are elongated columnar cells without intercellular spaces. These have chloroplast in them and are generally arranged in two layers.

(ii)Spongy parenchyma : It is found below palisade parenchyma and are spherical or oval with intercellular spaces. They also have chloroplasts but number of chloroplasts is more in palisade parenchyma than spongy parenchyma.

(d)Vascular bundles : Vascular bundles are. generally found at the boundary between the palisade and the spongy regions. The vascular bundle in midrib region is largest. Vascular bundles are conjoint, collateral and closed. Each vascular bundle is surrounded by a bundle sheath of parenchymatous cells. In the vascular bundle, xylem is present towards upper epidermis and phloem towards lower epidermis. Further in xylem, protoxylem is towards upper epidermis.

Structural Organisation in Animals Class 5 Notes Biology

Topic 1: Animal Tissues

Tissue
All cells are well organised and coordinated to work in a group. A group of similar cells along with intercellular substances perform a specific function, such an organisation is called tissue. The term 'Tissue' was introduced by Bichat and he is known as the father of animal histology.

A tissue can also be defined as a group of one or more types of cells having a same origin and specialised for specific functions along with the intercellular materials. The intercellular materials or fluid forms the environment of the cell. The cell receives almost all the materials it require from the intercellular fluid and transfer its waste materials again in this fluid.

Note:

- The microscopic study of the tissues and organs in relation to their function is called Histology.
- The term Histology was coined by Mayer, in 1819.
- The tissues arise from the undifferentiated cells of the primary germ layers (ectoderm, mesoderm and endoderm) in an embryo.Types of Animal Tissues
- The structure of the cells vary according to their function.

This variation in cells leads to the formation of following four types oftissues on the basis of their location andfunction
(i) Epithelial (ii) Connective
(iii) Muscular (iv) Neural

I. Epithelial Tissue
Epithelial tissue or epithelium (Epi – upon; thele – nipple) covers both external and internal surfaces of the animal body. The epithelial tissue has a free surface, which faces either a body fluid or the outside environment and thus, provides a covering or a lining for some part of the body.

Characteristics
The characteristic features of epithelial tissue are as follows
(i) The cells are compactly arranged.
(ii) Intercellular spaces are narrow, 20-30 nm wide.
(iii) Adjacent cells are held together by intercellular junctions.
(iv) The epithelial tissue lies on a thin, non-cellular basement membrane.
(v) Blood vessels are not present in the epithelial tissue.
(vi) Materials are exchanged by diffusion between epithelial cells and the blood vessels of the connective tissues across the basement membrane.
(vii) Nerve endings may penetrate the epithelial tissues.

Junctions Between Epithelial Cells
The common intercellular junctions may include tight junctions, gap junctions, desmosomes, intercellular bridges and interdigitations.

Tight Junctions
The plasma membrane in the apical region of the adjacent epithelial cells become tightly packed together. These junctions check the flow of materials between the cells and are called occluding junctions.

Adhering Junctions
Facilitate the cementing process so as to keep the * neighbouring cells together. They include desmosomes and hemidesmosomes.

Desmosomes
These are thick and strong junctions. They serve, anchoring functions.

Gap Junctions
They are fine hydrophilic channels between adjacent cells formed with the help of protein cylinders called connexin. They help in chemical exchange between adjacent cells and hence are called communicating junctions.

Types of Epithelial Tissues
The epithelial tissues are broadly classified into two groups, i.e., simple and compound.

Simple Epithelia
Simple epithelium is made up of a single layer of compactly arranged cells which rest over a non-cellular basement membrane. It occurs over moist surfaces where a little wear and tear occurs by friction. The simple epithelium is generally related with absorption, secretion, diffusion and movement of materials.
It is further sub-divided into following types

i. Simple Squamous Epithelium
The squamous (squama-scale) is formed of a single layer of closely fitted, flattened, polygonal cells, which forms bulges on the cell surface.The given cells are held together by various types of junctions, mainly tight junctions. The cells of squamous epithelium appear as tiles over a floor. They are also known as pavement epithelium.

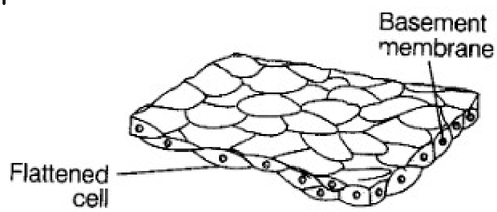


Fig. 7.1 Simple squamous epithelium

The squamous epithelium occurs in the alveoli of the lungs, Bowman's capsule, Henle's loop of uriniferous tubules, pericardial cavity, abdominal cavity, lining of various components of blood vascular system.
Functions Simple squamous epithelium performs the function of protection, excretion, gas exchange and secretion of coelomic fluid.

ii. Simple Cuboidal Epithelium
It is composed of a single layer of cube-like cells. The epithelium overlies on the basement membrane. Nucleus is rounded and placed centrally. The free surfaces of

the cells may be smooth or bear microvilli. The microvilli increases the surface area of free ends of cells by many times.

The simple cuboidal epithelium is commonly found in the ducts of glands, tubular parts of nephrons in kidneys, ovaries seminiferous tubules of testes, etc.

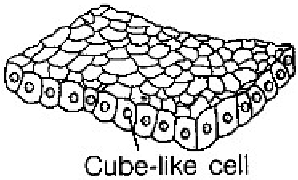


Fig. 7.2 Simple cuboidal epithelium

Functions The main function of this epithelium is protection, secretion, absorption, excretion and gamete formation.

iii. Simple Columnar Epithelium

It is composed of a single layer of tall and slender cells. A single oval or elongated nucleus is situated near the base of the cell. Some of its cells produce mucus, called goblet cells.

The simple columnar epithelium occurs in the lining of stomach, small and large intestine, digestive glands of stomach, intestine and pancreas, gall bladder, etc.

The brush border columnar epithelium occurs in the gall bladder. The mucus secreting goblet cells are found in the lining layer of stomach, intestine, respiratory tract, etc.

Functions The simple columnar epithelium helps in secretion, absorption and protection to the components of most glandular epithelia.

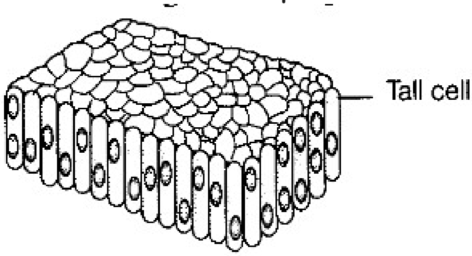


Fig. 7.3 Simple Columnar epithelium

iv. Simple Ciliated Epithelium

If the columnar or cuboidal cells bear cilia on their free surface they are called ciliated epithelium. They move particles or mucus in a specific direction over the epithelium. The epithelium lies over a basement membrane. The number of cilia varies in different cellular forms.

In sensory cells of internal ear, a cilium accompanies number of stereocilia.

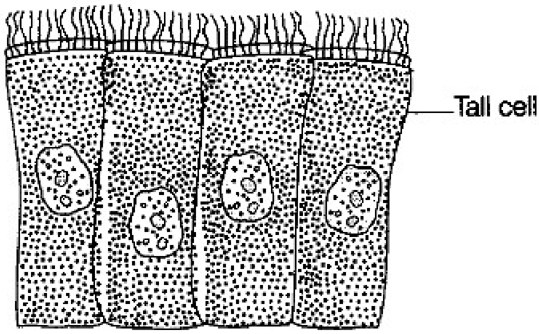


Fig.7.4 Simple columnar cells bearing cilia epithelium

This epithelium is of two types, i.e., ciliated columnar and ciliated cuboidal.
(a) Simple Ciliated Columnar Epithelium It possess columnar cells that possess cilia over their free surface. It occurs in respiratory tract, fallopian tubes, parts of uterus and cervix, the different tubules of testes, etc.

(b) Simple Ciliated Cuboidal Epithelium It has cuboidal or cubical cells that bear cilia on their free surface. It occurs in many parts of ependyma of nervous system and parts of uriniferous tubules.

Functions The epithelium maintains a flow of mucus, liquid or suspended particles constantly in one direction. In the oviducts, cilia helps in the movement of egg towards the uterus. In respiratory tract, cilia helps to push the mucus towards the pharynx. In nephrons of kidney, cilia keep the urine moving.

In nervous system, cilia of the ventricles of the brain and central canal of the spinal cord helps in the circulation of cerebrospinal fluid.

Pseudostratified Epithelium

The epithelium is one-cell thick, but appears 2-layered because all the cells do not reach the free surface. The cells are attached to the basement membrance, hence they are called pseudostratified. The mucus secreting goblet cells also occur in this epithelium.

This epithelium is of two types
(a) Pseudostratified Columnar Epithelium It has columnar cells without cilia. It lines the large ducts of certain glands, like parotid salivary glands and the urethra of human male.

(b) Pseudostratified Ciliated Columnar Epithelium It has columnar cells. The tall cells bear cilia at the free surfaces and the short cells are without cilia. The epithelium lines the trachea and large bronchi. The movements of its cilia push the mucus laden with dust particles and bacteria towards the larynx.Functions The pseudostratified epithelium helps in protection, movement of secretions from glands, urine and semen in urethra and mucus loaded with dust particles and bacteria in trachea.

Compound Epithelia
The compound epithelium is made up of more than one layer of cells. They cover the surfaces where constant replacement of cells is required due to rapid wear and tear by friction.

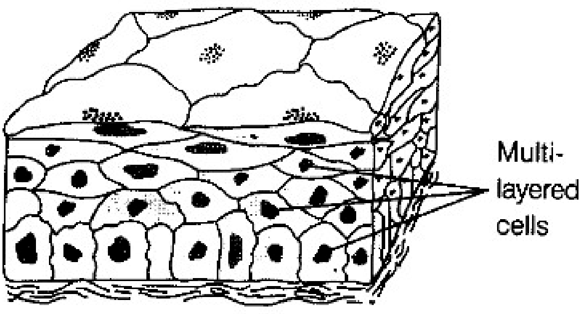


Fig.7.5 Compound epithelium

The compound epithelia are of two types, i.e., stratified and transitional.
(a)Stratified Compound Epithelia
The stratified epithelia consist of many layer of cells. On the basis of the shape of the cells present in the superficial layers, the stratified epithelia are of four types (a) Stratified Squamous Epithelium The cells in the basal (deepest) layer are columnar or cuboidal with oval nuclei. It is called germinative layer. The cells in this region divide by mitosis to form new cells.

The stratified squamous epithelium is further sub-divided as two main types, i.e., keratinised and non-keratinised.

Keratinised Stratified Squamous Epithelium The cells of the outer few layers replace their cytoplasm with a hard waterproof protein called keratin or horn. This is called keratinisation or cornification. These layers of flat, dead cells are called stratum corneum or homy layer.

The heavy deposits of keratin in the dead superficial cells makes the epithelium impervious to water and highly resistant to mechanical abrasions. This epithelium forms the epidermis of the skin in land vertebrates.

Non-keratinised Stratified Squamous Epithelium This epithelium does not have keratin and is unable to check water loss. It provides moderate protection against abrasion. It lines the buccal cavity, pharynx, oesophagus,
canal, lower part of urethra, vocal cord, vagina, cervix (lower part of uterus), conjuctiva, cornea of eye and inner surface of eyelids.

(b) Stratified Cuboidal Epithelium It has outer layer of cuboidal cells and basal layer of columnar cells. It forms the epidermis of fishes and many urodeles (tailed amphibians like salamanders). It also lines the sweat gland ducts and larger salivary and pancreatic ducts.

(c) Stratified Columnar Ciliated Epithelium Its outer layer consists of ciliated columnar cells and basal layer of columnar cells. It lines the larynx and upper part of the soft palate.

(d) Stratified Columnar Epithelium It consists of columnar cells in both superficial and basal layers. It covers the epiglottis and lines mammary gland ducts and parts of urethra.

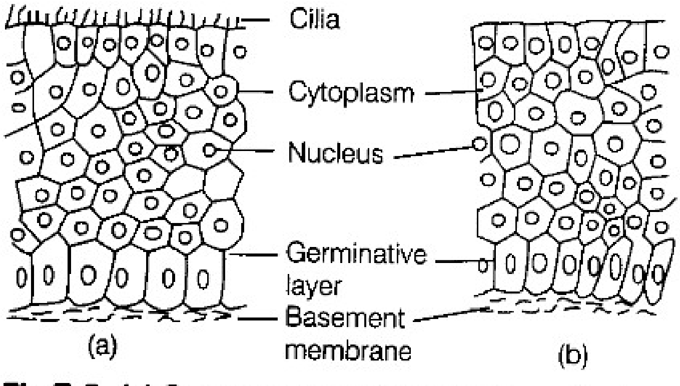


Fig.7.6 (a) Stratified ciliated columnar epithelium
(b) Stratified columnar epithelium

ii- Transitional Compound Epithelium

The epithelium consists of more than one layer of cells, but is much thinner and more stretchable than the stratified epithelium. It contains cuboidal cells at the base, two or three layers of large polygonal or pear-shaped cells in the middle and a superficial layer of large, broad, rectangular or oval cells.
The transitional epithelium lines the inner surface of urinary bladder, ureter and renal pelvis. They have thick membrane with thin regions that fold when the bladder contracts.

3. Glandular Epithelium

Some of the columnar or cuboidal cells get specialised for secretion and forms the glandular epithelium.
It is of two types

Unicellular Glandular Epithelium

It consists of isolated glandular epithelial cells called intraepithelial cells, e.g., Goblet cells of the alimentary canal are one such cell.u. Multicellular Glandular Epithelium
It consists of cluster of epithelial cells called extra epithelial cells. These cells unite to make up one gland, e.g., Salivary gland.

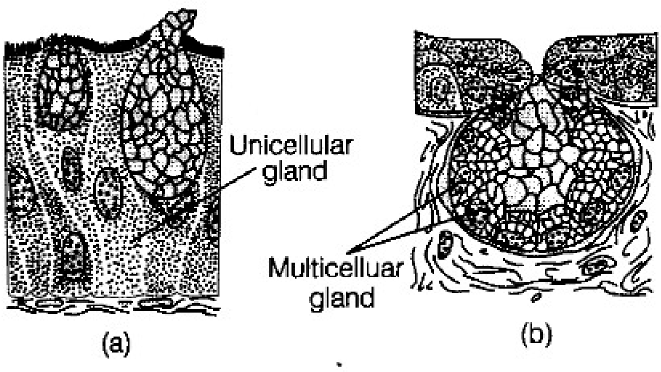


Fig 7.7 Glandular epithelium (a) Unicellular (b) Multicellular

Gland

A cell, tissue or organ, which secretes some substance is called a gland. The secretions of glands may be protein (pancreas), lipids (adrenals), mixture of carbohydrates and proteins (salivary gland) or mixture of all the three materials (mammary glands).

The glands can be classified in different types based on site of secretion, mode ofsecretiori and involvement of single or many cells.

Based on Site of Secretion
The glands can be exocrine, endocrine or heterocrine based on the site where the secretion is released.
(a) Exocrine Glands These glands have ducts to pour their secretions to their site of action. They often secrete enzymes and its examples include salivary glands, intestinal glands, gastric glands, lacrimal or tear glands.

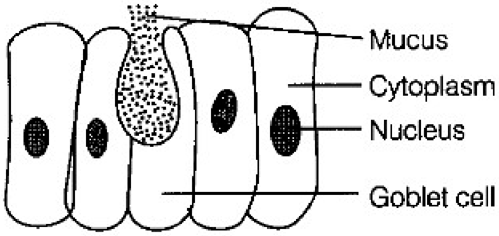


Fig. 7.8 Unicellular glands

(b) Endocrine Glands These glands do not have ducts and pour their secretions directly into the blood or lymph. These glands are also called ductless glands and their secretions are known as hormones. Some examples of endocrine glands are pituitary, thyroid, parathyroid, adrenal, etc.

(c) Heterocrine Glands/Myxocrine Glands These glands are partly exocrine and partly, endocrine in function, e.g., Pancreas, kidneys, stomach, gonads, intestine, placenta, etc.

Based on Number of Cells
According to the number of cells forming the glands, they are unicellular and multicellular.
(a) Unicellular Glands The mucus secreting goblet cells of the alimentary canal are called unicellular glands.

(b) Multicellular Glands These are composed of many cells and are formed by sinking of the gland into the underlying connective tissue. The multicellular glands may be simple or compound glands

- * Simple Glands These may be simple tubular glands, e.g., Crypts of Lieberkuhn, simple coiled tubular glands (sweat glands) and simple alveolar glands having flask-shaped secretory units (mucus secreting glands in the skin of frog.)
- Compound Glands These have branch system of ducts. These may be compound tubular glands {e.g., Gastric glands of stomach, Brunner's glands of

intestine), compound alveolar glands {e.g., Some sebaceous glands and salivary glands) and compound tubuloalveolar glands having both tubular and alveolar secretory units {e.g., Pancreas, functional mammary glands).
Functions of Epithelial Tissue

The main functions of epithelial tissue are listed below
(i) The epithelial tissue protects the underlying tissues from mechanical injury, entry of germs, harmful chemicals and drying up.
(ii) It checks the absorption of harmful or unnecessary materials.
(iii) The epithelium of uriniferous tubules is specialised for urine excretion.
(iv) The sensory epithelia of sense organs help to receive various stimuli from the atmosphere and convey them to the brain.
(v) The epithelium of alveoli of the lungs brings about the exchange of gases between the blood and air.
(vi) The pigmented epithelium of the retina darkens the cavity of eyeball.
(vii) Epithelium also forms glands that secrete secretions such as mucus, gastric juice and intestinal juice.
(viii) The germinal epithelium of the ovaries and seminiferous tubules of the testes produce ova and sperms, respectively.(ix) Epithelium produces exoskeletal structures like scales, feathers, hair, nails, claws, horns and hoofs.
(x) Ciliated epithelia (e.g., of respiratory and genital tracts) serves to conduct the mucus and other fluids in the ducts they line.

Note:

- The term 'Epithelium' was coined by Ruysch.
- Transitional epithelium

ii. Connective Tissue
The connective tissues are most abundant and widely distributed in the body of complex animals. They are named as connective tissues because of their special function of linking and supporting other tissues/organs of the body.

Generally, connective tissue is made up of three components
1. Matrix
It is a clear and viscous substance. Its consistency may vary from liquid (e.g., blood) to semi-solid (e.g., cartilage) and solid (e.g, bone) form.

2. Cells Embedded in the Matrix

These are responsible for secreting the matrix and other substances.
The cells of connective tissue are of different types

(i) Fibroblasts produce fibres and matrix.

(ii) Adipose cells store fat.

(iii) Plasma cells synthesize antibodies. These are also called 'cart wheel cells' because thin chromatin in their nucleus forms four or five clumps giving the nucleus a resemblance of a cart wheel.

(iv) Mast cells produce histamine, heparin and serotonin. These are related to basophils of the blood.

(a) Histamine dilates the walls of blood vessels in inflammatory and allergic reactions.

(b) Heparin checks clotting of blood inside the blood vessels.

(c) Serotonin acts as a vasoconstrictor to check bleeding and to increase the blood pressure.

(v) Mesenchyme cells produce various types of connective tissue cells.

(vi) Macrophages ingest cell debris, bacteria and foreign matter.

(vii) Chromatophores (pigment cells) are found in the dermis of the skin which impart colour to the animals.

(viii) Reticular cells form reticular tissue and are phagocytic in nature.

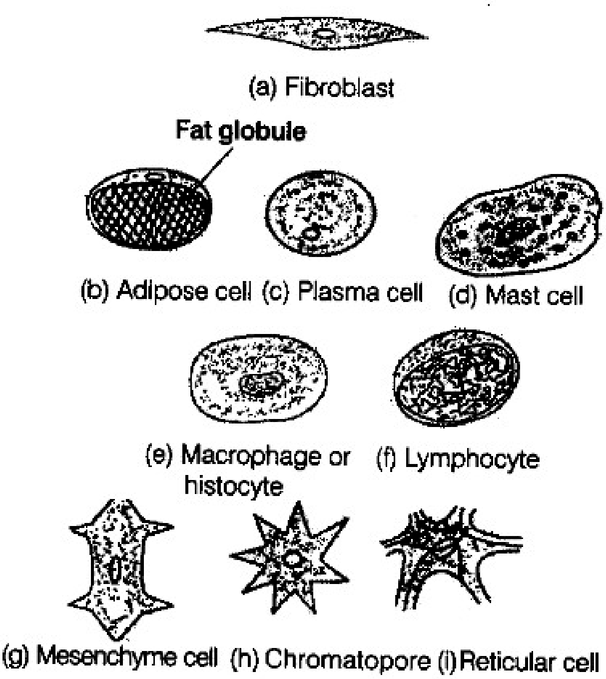


Fig. 7.9 Cells of Connective tissues

3. Fibres
These are non-living products of the cells.

These are of three types
(i) Collagen or Collagenous fibres (white fibres) are made up of collagen protein. When boiled in the water, collagen changes into gelatin.
(ii) Elastic fibres (yellow fibres) are formed of a protein called elastin. These fibres are branched and elastic.
(iii) Reticular fibres are delicate, branched and inelastic. They are made up of reticulin protein. They always form a network.

Types of Connective Tissues

The connective tissues are mainly of following three types

1. Loose Connective Tissue
Loose connective tissue has cells and fibres loosely arranged in a semi-fluid ground substance. These tissues are of two types, i. e., areolar tissues and adipose tissue.

Areolar Tissue
It is found under the epithelial tissue of the skin, visceral organs like stomach, trachea and the walls of the blood vessels, etc. Its matrix is made up of glycoproteins. It contains two types of fibres, i.e., the white collagen fibres made up of collagen and the yellow elastic fibres made up of elastin. The different cells of areolar tissue are fibrocytes, macrophages and mast cells.

Functions The tensile strength of collagen fibres and the elasticity of the yellow fibres protect the various organs from mechanical injuries.

This tissue also provides rapid diffusion of the materials and migration of wandering cells towards the areas of infection and repair.

Adipose Tissue
It is a modified type of areolar tissue. Its matrix contains large number of adipose cells along with fibrocytes and macrophages. White and yellow fibres are present in the matrix. The cells of this tissue are specialised to store fats.
The excess of nutrients which are not used immediately are converted into fats

and are stored in this tissue. The adipose tissues are found in the subcutaneous region, around the heart, kidneys, eyeballs, etc. e.g., It is also found in the blubber of whales and elephants, hump of camel, fat bodies of frog and yellow bone marrow.

Functions The adipose tissue is mainly a food reserve or fat depot for storage. It forms a shock-absorbing cushion around the eyeballs and kidneys. The tissue also helps in the production of blood corpuscles.

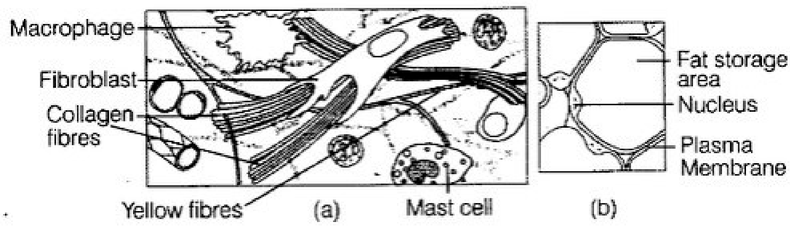


Fig. 7.10 Loose connective tissue (a) Areolar (b) Adipose tissue

2. Dense Connective Tissue
Fibres and fibroblasts are found compactly packed in the dense connective tissues. This tissue is of two types i.e., dense regular and dense irregular connective tissue.

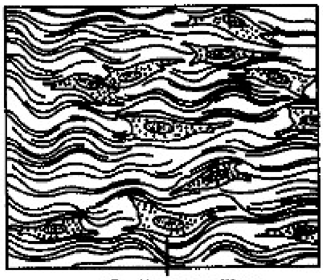
i. Dense Regular Connective Tissue
In this tissue, the collagen fibres are present in rows between many parallel bundles of fibres.

It is further of two types
It mainly consists of white fibres arranged in bundles. The fibroblasts are present in rows between the bundles.

It is of two types
Tendons The white fibrous connective tissue forms the cords called tendons. These join the skeletal muscles with the bones.

Sheets The white fibrous connective tissue also forms flat plates or sheets. It occurs in the dermis of the skin, periosteum of the bone, perichondrium of Fi8-7'11 Dense re9ular cartilage, pericardium of heart etc .The white fibrous connective tissue has great strength however its flexibility is limited.

It mainly consists of yellow elastic fibres. The fibres are thicker. The fibroblasts and a few white fibres are found in between the yellow fibres.



Collagen fibre

Fig.7.11 Dense regular

It is also of two types

Ligaments The yellow elastic connective tissue forms the cords called ligaments. These join bones to bones.

Sheets The yellow fibrous sheets formed by this tissue occur in the walls of blood vessels, lungs and bronchioles, true vocal cords, cartilage of larynx, trachea etc.

The yellow elastic connective tissue has considerable strength and remarkable elasticity. Thus, it allows the stretching of various organs.

Dense Irregular Connective Tissue. It has fibroblasts and many fibres (mostly collagen) that are oriented in different pattern. This tissue is present in the skin. Collagen fibre

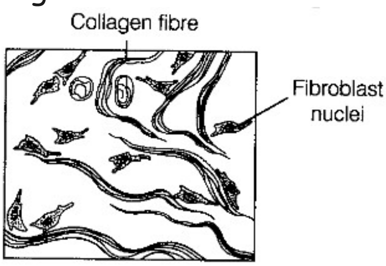


Fig.7.12 Dense irregular

3. Specialised Connective Tissues

The specialised connective tissues are of following types

Skeletal Tissues

These tissues form the endoskeleton of the vertebrates. They form a rigid framework which supports the body, protects the vital organs and helps in locomotion.

The two types of skeletal tissues, i.e., cartilage and bone.

a. Cartilage

It is a tough, semitransparent, elastic and flexible tissue. The cartilage cells lie in groups of 2-3 in fluid filled spaces called lacunae. The cartilage is bounded

externally by a stiff sheath called perichondrium containing white fibrous, tissue. The cartilages are of three types, i.e., hyaline, fibrous and calcified.
Hyaline Cartilage It has a clear, translucent, bluish green matrix. It is flexible and forms articular surfaces at the joints of long bones, where it is called articular cartilage.

Fibrous Cartilage It has well-developed fibres in the matrix. It is of two types i.e., white fibrous cartilage and yellow elastic cartilage.

It is a hard and rigid connective tissue. These are non-pliable ground substance rich in calcium salts and collagen fibres providing strength to the bone. The cells of bone are found in a calcified matrix made up of ossein. The bone cells known as osteocytes lodged in the spaces called lacunae.

They also interact with skeletal muscles attached to them to bring about movements.
The bone consists of four parts, i.e.,

Periosteum It is a thick and tough sheath that forms an envelope around the bone. It is composed of collagen fibrous tissue. The periosteum contains blood vessels. It also contains bone-forming cells, the osteoblasts, which produce new bone material.

Matrix It is composed of a protein called ossein. The Haversian canals, a characteristic feature of mammalian bones are present in the matrix. Each Haversian canal contains an artery, a vein, a lymph vessel, a nerve and some bone cells.

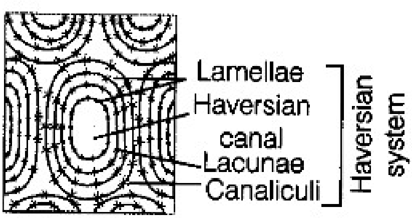


Fig.7.14 Bone

• Endosteum It is present outer to the bone marrow cavity. It comprises white fibrous tissue and the bone forming cells called osteoblast. The latter produces new bone material.

• Bone Marrow It is the vascular, soft pulpy connective tissue found in the bone marrow cavity of long bones like humerous, femur, etc.

Bone marrow is of two types
• Yellow marrow (rich in fat cells called adipocytes.) and
• Red marrow (Blood cells are formed in this marrow.)
In foetus, red marrow occurs in all bones. After birth, it restricts to limited places.
Calcified Cartilage When matrix of cartilage contains granules of calcium carbonate, the cartilage is called calcified cartilage.The bones can be spongy or compact on the basis of density and texture.

(a) Spongy (cancellate) Bone It contains a network of thin and irregularly longitudinal and transverse bony bars called trabeculae covered by the endosteum. It is found at the ends of long bones (epiphyses).

(b) Compact (Dense) Bone It is hard and compact and found in the shaft of long bones. It contains yellow bone marrow and has Haversian systems.

In a decalcified bone, the inorganic part of the matrix is removed. For deealcifieation, the bone is kept in dilute hydrochloric acid for long hours. This is to study living structures of the bone as it dissolves all the inorganic salts leaving behind only the organic matter.

Vascular Tissues
These are motile connective tissues consisting of fluid matrix and free cells. The matrix is without fibres. The vascular tissue helps in the transport of materials from one place to another.

Blood
It is a mobile, watery fluid with a slightly salty taste. It is composed of plasma (a fluid matrix) and the cells called blood corpuscles. It is bright red in colour when oxygenated and purple when deoxygenated. The volume of blood in an adult is about 5L.
It circulates within the blood vessels in higher animals. It is slightly alkaline (pH 7.4) in nature.

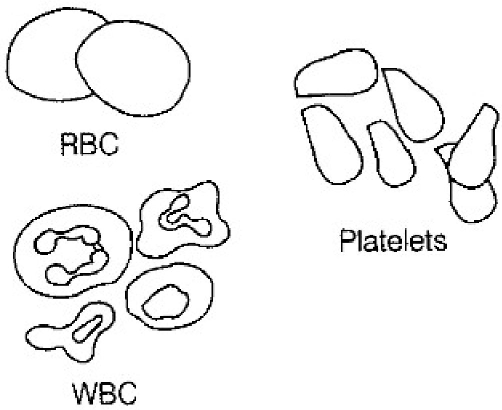


Fig 7.15 Specialised Connective tissue Blood

Plasma is a yellowish, straw-coloured liquid which is composed mainly of water (92%). About 55% of the total blood volume is plasma. The solid materials in plasma include plasma proteins, nutrients (glucose, amino acids, fatty acids and vitamins), hormones, antibodies, enzymes, lactic acid, cholesterol, dissolved gases (oxygen, carbon dioxide), mineral salts and waste products (urea; uric acid and creatinine). Functions It helps in transport of substances, provide body immunity, prevent the blood loses, retain fluid in blood, maintain blood pH and conduct heat to skin for dissipation.

Blood Cells

The blood cells or blood corpuscles forms about 45% of the blood volume. These cells are formed in the bone marrow of the long bones and the lymph nodes. The process of blood cells formation is called haemopoiesis and the tissues where these are formed are called haemopoietic tissues.

The blood cells are of following types

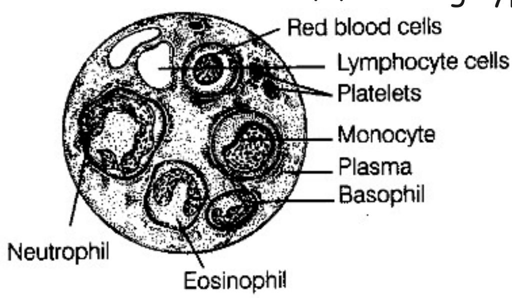


Fig.7.16 Blood Cell

- Erythrocytes or Red Blood Corpuscles (RBCs) are the most abundant elements in blood. These carry red-coloured oxygen carrying pigment called haemoglobin. They are 7-8 |Xm in diameter.

- The human RBCs are smaller than the white blood corpuscles. In mammals, they are non-nucleated, biconcave and circular. The formation of erythrocytes is called erythropoiesis.
- Leucocytes or "White Blood Cells (WBCs) lack haemoglobin and are colourless. They are nucleated with rounded or irregular shape. They can change their shape and are capable of amoeboid movement.
- Thrombocytes (Blood Platelets) These are small, colourless, plate like discs having size of about 2-3 pm. Their number ranges between 0.15-0.4 million/mm3 of blood. Their normal life span is about a week. No nucleus is visible in these cells.

The blood performs following functions in the animal body.

- Blood transports oxygen from the respiratory organs to the tissues and carbon dioxide from the tissues to the respiratory organs.
- It transports nutrients to all parts of the body.
- Blood maintains the constant body temperature by distributing the heat throughout the body.
- Lymphocytes and eosinophils produce antitoxins to neutrilise the toxins, released by the microbes.
- Blood helps to maintain water balance to a constant level by bringing about constant exchange of water between circulating blood and tissue fluid.
- It helps to regulate the pH of the body fluids as it contains buffer materials such as proteins and mineral salts.
- Blood helps in healing of injuries by maintaining necessary supplies for the repair of damaged tissues.

It is a mobile connective tissue comprising lymph plasma (fluid) and lymph corpuscles (cells). It is pale yellow in colour and its composition is similar to plasma without the plasma proteins. It is present in the vessels called lymph vessels.

Lymph is formed of liquid components and formed elements or cells. It contains about 94% water and 6% of organic and inorganic substances. The organic part includes protein, fat droplets, carbohydrates, nitrogenous wastes and hormones.

Lymph performs the following functions in animal body
(i) It plays an important role in the defence of the body especially against invading organisms.

(ii) The digested products of fat digestion enter the lymph vessels present in the villus of the small intestine.
(iii) Lymph helps to maintain the blood volume by returning the interstitial fluid back to the blood during circulation.
(iv) The lymph nodes produce lymphocytes.
(v) It keeps the tissue cells moist.

4. Reticular Connective Tissues
Tissues consist of star-shaped reticular cells whose protoplasmic processes joins to form a cellular network. The reticular fibres are present on the reticular cells (composed of a protein called reticulin.)
The reticular connective tissue is present in the liver, spleen, lymph nodes, thymus, tonsils, bone marrow and lamina propria of the gut wall.

Function This tissue provides strength and support as it forms the supporting framework of many organs. It also helps to bind together the cells of smooth muscles. The reticular cells are phagocytic – and forms the defense mechanism of the body.

5. Pigmented Connective Tissue
The cells of pigmented connective tissue are irregular and are called pigment cells (chromatophores or melanophores). These cells contain yellowish brown, black or blue melanin pigment granules. Melanin is produced by other cells called melanocytes.

This tissue is present in the choroid, ciliary body and iris of the eye and dermis of the human skin.
Functions It gives colour to the structures.

6. Mucoid Connective Tissue
This tissue occurs as a foetal or embryonic connective tissue as it is present in the umbilical cord. The mucoid tissue contains a jelly like substance called Whartson's jelly and some delicate collagen fibres and primitive type of fibroblasts. It occurs as embryonic connective tissue in the foetus and vitreous humour of the eye.

Functions of Connective Tissue

The connective tissue performs fallowing main junctions
(i) The connective tissue mainly joins one tissue to another in the organs.
(ii) The adipose tissue stores fat.
(iii) The cartilage and bones form a supporting framework for the body.
(iv) Blood and lymph carry materials from one part to another in the body.
(v) The cells of connective tissues like macrophages, monocytes, neutrophils ingest bacteria, cell debris and foreign materials.
Thus, they protect and clean the body.
(vi) The adipose tissue acts as shock absorber around some organs, such as eye balls and kidneys. It also acts as packing material in various organs.
(vii) Bone marrow is the source of blood corpuscles.
(viii) The collagen fibres help in the repair of injured tissues.

Note:

- In old age, the bone marrow of the cranial bones undergo degeneration and is called gelatinous marrow.
- Bone marrow is a special kind of myeloid (myelogenous) tissue.
- Prothrombin and fibrinogen are the largest blood proteins and albumins.are the smallest one.

i. Muscular Tissue

The striated muscle fibres are multinucleated or syncytial in nature. The cytoplasm (sarcoplasm) of each fibre has a large number of myofibrils (actin and myosin myofibrils) which are tightly packed.
Each myofibril shows dark and light bands of stripes alternating with each other. Hence, they are called as striped muscle fibres.

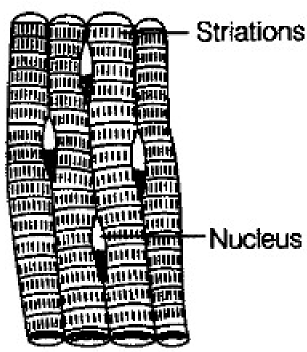


Fig. 7.17 Skeletal (striated) muscle tissue

ii. Non-Striated (Smooth) Muscle

The non-striated muscles are found in the posterior part of oesophagus, stomach, intestine, lungs, urinogenital tract, urinary bladder, blood vessels, iris, ciliary body of eye, dermis of skin, etc.

The non-striated muscle consists of long, narrow, spindle-shaped fibres that are generally shorter than the striated muscle fibres. Their size may range from 20 |Xm (Small blood vessels) -500 (1m in pregnant uterus). Each non-striated muscle fibre contains a single oval nucleus in its thick middle part. In the cytoplasm, the myofibrils are arranged longitudinally. They are composed of myosin. There is no sarcolemma, however, the fibre is enclosed by the plasma membrane.

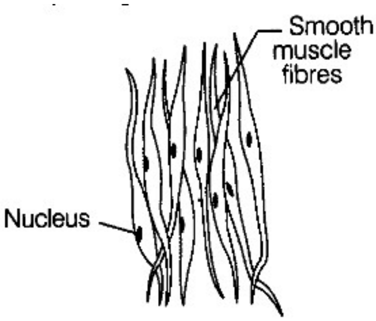


Fig. 7.18 Smooth muscle tissue

The smooth muscles help in the peristalsis which occurs in the tubular viscera. The autonomic nervous system controls these muscles. Hence, they are not under the control of animal's will.

iii. Cardiac Muscles

The cardiac muscles are contractile tissues present only in the heart and in the wall of large veins which enter the heart. The cardiac muscle fibres show the characters of both unstriped and striped muscle fibres.

The myofibrils have transverse faint dark and light bands which alternate with each other.

The cardiac muscle fibres have some specialfeatures

(i) These muscle fibres are supplied with both central and autonomic nervous system and are not under the will of the animal.

(ii) These fibres never get fatigue.

(iii) Blood capillaries penetrate the cardiac muscle fibres, hence they have very rich blood supply.

(iv) These fibres have the property of contraction, even when they are isolated from the body temporarily.

Functions of Muscular Tissues

The muscle tissues perform following important junctions

(i) These are involved in the movement of body parts and locomotion of the organism.

(ii) Muscles are responsible for heart beat, production of sound and peristalsis in tubular viscera.

(iii) The muscles support the bones and other structures.

(iv) Muscles are essential during parturition.

The neural tissue is ectodermal in origin. It is specialised to receive stimuli and conducts impulses for controlling and coordinating body functions. It exerts the greatest control over the body's responsiveness to changing conditions. The neural tissue consists of nerve cells and packing cells. The packing cells are called Schwann cells in the peripheral nervous system and neuroglia cells in the central nervous system.

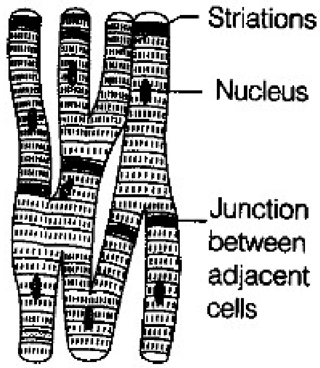


Fig. 7.19 Cardiac muscle tissue

The muscle tissue consists of elongated and contractile cells called muscle cells or myocytes. Due to their elongated nature, the muscle cells are also called muscle fibres. It develops from mesoderm. The muscle cells are surrounded by connective tissue. Each muscle cell is covered by a membranous sheath called sarcolemma.

It consists of plasma membrane and basement membrane. The cytoplasm of a myocyte is called sarcoplasm. The endoplasmic reticulum is called sarcoplasmic reticulum and the mitochondria are called sarcosomes. The myoglobin keeps the reserve oxygen for immediate supply during muscle activity.

It also provides light pinkish colour to the muscles. The muscle cells may be uninucleate or multinucleate. The contractile structures of muscle cells are called myofibrils. The myofibrils are made of myofilaments. The myofilaments are of two types, i.e., thicker myosin and thinner actin. The contraction of muscles occurs due to sliding of actin filaments passing over the myosin filaments.

Types of Muscles

The muscles can be grouped into three types based on their structure, location andJunction.

(i) Striated or striped or skeletal or voluntary muscles.

(ii) Non-striated or unstriped or visceral or smooth or involuntary muscles. .

(iii) Cardiac muscles.

(iv) Striated Muscles

The striated or skeletal muscles form about 40% of total body weight. These muscles are attached and bring about the movement of the various bones of the skeleton, so are called skeletal muscles. The striated muscles give shape to the body and also release heat during contraction. These muscles have huge supply of nerves and blood vessels. Each striated muscle is a long, narrow, cylindrical, unbranched cell.

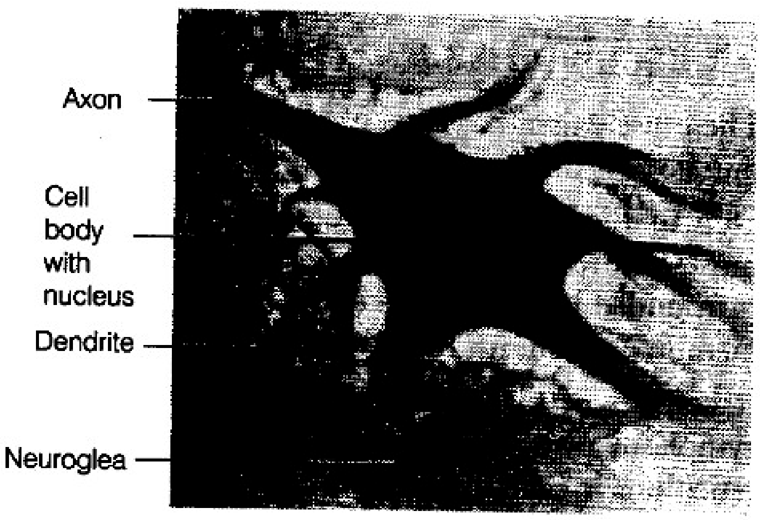


Fig. 7.20 Neural tissue (Neuron with neuroglia)

Nucleus

It is a long and cylindrical structure which has a definite sarcolemma. The fibres are uninucleate and the nuclei lie near the centre.

Neurons

Neurons are the functional unit of neural system. These are excitable cells. A neuron consists of a cell body (cyton) or soma and fine protoplasmic processes called neurites arising from the cell body.

i. Cyton
It contains neuroplasm (cytoplasm), a spherical nucleus, endoplasmic reticulum, mitochondria, Golgi bodies, ribosomes, lysosomes, fat globules, Nissl's granules etc. The Nissl's granules are probably involved in the synthesis of proteins.

Neurites
The processes arising from the neurons are called neurites. These are dendrites and an axon. Axon is single, but dendrites may vary from one to several. The dendrites are usually shorter and tapering processes. The axon is usually a long process of uniform thickness.

Nerve Fibres
The nerve fibres are elongated and slender processes of the neurons, which are formed by ensheathing of axons. A space of 15-20 nm occurs between axolemma and the covering sheath. It is called periaxonal space.

Depending upon the covering sheath, nerve fibres are of two types
(a) Myelinated Nerve Fibre
An axon covered by myelin sheath is called myelinated or medullated nerve fibre. The myelin contains lipids, proteins and water. The medullary sheath serves as an insulating layer, preventing loss of energy of the nerve impulse during its passage along the fibre./; Non-Myelinated Nerve Fibres

A non-medullated or non-myelinated fibre consists of an axis cylinder enclosed by neurilemma and connective tissue. It lacks medullary sheath and appears grey in the fresh state.

On the basis of function also, the nerve fibres are of two types (a) Afferent (Sensory) Nerve Fibres The afferent nerve fibres carry the nerve impulses from the sense organs to the central nervous system (brain and spinal cord).

(b) Efferent (Motor) Nerve Fibres
They carry nerve impulses from the central nervous system to the effector organs (muscles and glands).
Nerves
A nerve is a complex bundle of nerve fibres enclosed together by a common sheath

of connective tissue along with the blood vessels. Each nerve fibre is covered by a thin sheath of connective tissue called endoneurium.

A number of nerve fibres, each covered by its own endoneurium are joined together to form a bundle called fasiculus or fascicle.

According to the nature of fibres, nerves can be of following three types
(i) Sensory (Afferent) nerves These nerves bring sensory impulses or excitation from different parts of the body and sense organs.
(ii) Motor (Efferent) nerves These nerves carry message from central nervous system to parts of the body and effector organs to perform their function.
(iii) Mixed nerves The nerves contain both sensory and motor fibres.

Neuroglia
The neuroglia or glia cells are supporting cells which form a packing around the neurons in the brain, spinal cord and ganglia. These cells have different shapes and many processes. The neuroglia cells have various roles like myelin formation, transport of materials to neurons, maintenance of ionic balance and phagocytosis.

Neurosecretory Cells
These are specialised neurons or neuron-like cells, which secrete biologically active substances that are effective in other structures, often at a different site. The neurosecretory cells occur in hypothalamus. They produce hormones called neurohormones.

Functions of Neural Tissue
Neural tissue perform the following functions
(i) The neural tissue coordinates and controls the functioning of different parts of the body.
(ii) The sensation of smell, vision, taste, hearing, pain, pleasure, etc., are performed through the nervous tissue.
(iii) The neural tissue helps in meditating conscious activities.
(iv) The information about the changes in various internal structures is provided by nerves.
(v) It makes us aware about the environment around us.
(vi) The nervous tissue brings about an appropriate response to each and every

stimulus.
(vii) The tissue is also a seat of experiences, memories, etc.

Topic 2. Morphology and Anatomy of Animals

In this topic we will discuss morphology and anatomy of three organisms— Earthworm, Cockroach and Frog representing invertebrates and vertebrates at different evolutionary levels to show their organisation and functioning.
Morphology refers to study of from or externally visible features. The word anatomy is conventionally used for the study of morphology of internal organs in the animals.

Earthworm
Earthworm is a reddish-brown terrestrial invertebrate that inhabits the upper layer of the moist soil. During day time, they live in the burrows made by boring and swallowing the soil.
In the gardens, they can be find out by their faecal deposits called as worm castings. The two common Indian species of earthworms are Pheretima and Lumbricus.
Systematic Position

Kingdom	Animalia
Phylum	Annelida (metameric segmentation)
Sub-class	Clitellata (presence of clitellum and fewer setae, absence of head and parapodia).
Order	Haplotaxida (terrestrial and no asexual reproduction)
Family	Megascolecidae (male pores are behind the clitellum).
Genus	*Pheretima* (setae occur in a complete ring on almost all segments of the body, clitellum extends over 14-16 segments).
Species	*posthuma* (genital papillae are on the 17th and 19th segments, male genital pores on 18 th segment).

Earthworms inhabit almost all areas over the world, except the Arctic and Antarctic regions. There are about 500 species of Pheretima of which 13 species occur in India.

Habitat and Habit
Earthworm lives in moist soil rich in humus they are nocturnal animals (i.e., they come out at night for feeding and to mate and sleep during the day time).

Locomotion
The earthworm moves by crawling (creeping) in which its body remains on the ground. It moves by muscular contraction and relaxation of the body which is aided by chitinous setae or chaetae. It moves about 15 cm/min.

Food
The earthworm eats decaying organic matter found in the soil. It is omnivorous. The food is digested in the gut and undigested food along with the soil is passed out through the anus as small pills called worm castings.

Breeding
Earthworm is a hermaphrodite (i.e., bisexual or monoecious). It breeds in the rainy season. It is protandrous (i.e., male sex organs mature earlier than the female). Thus, self fertilisation is not possible, only cross fertilisation occurs in them.

The copulation occurs when two earthworms closely attach to each other by their ventral surfaces in a way that the head region of one is opposite to the tail region of the other. Then, the two worms separate after the exchange of spermatozoa.

Several eggs and spermatozoa are packed in an egg case, the ootheca (cocoon), which is deposited just beneath the surface of ground. About four baby earthworms develops in one cocoon.

Regeneration
The earthworm has great power of regeneration. If it is cut into two parts, its anterior half develops into tail, but in the posterior half, the head can be formed only if 4-6 anterior segments are removed.

Defence
Earthworm can defend itself only by ejecting the foul smelling coelomic fluid through the dorsal pores.

Morphology

Size, Shape and Colour

It has a long, cylindrical body. The anterior end is pointed, but there is no distinct head. The posterior end is rounded. The size of an adult worm is about 150 mm long and 3-5 mm wide. The dorsal surface is a bit darker than the ventral surface and bears a dark median line.

Perostomium

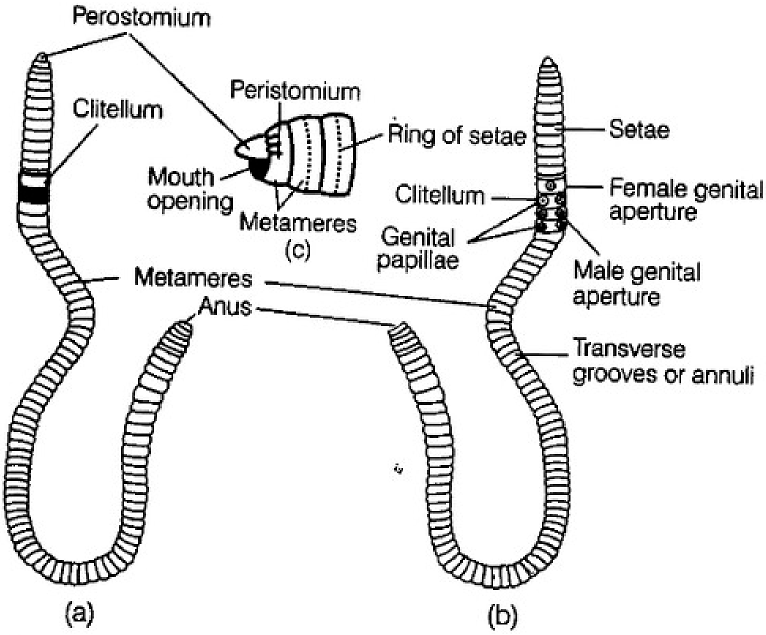


Fig. 7.21 Body of earthworm (a) Dorsal view (b) Ventral view (c) Lateral view showing mouth opening

Segmentation

The body of earthworm is divided into more than hundred short segments, which are similar (metameres, about 100-120 in number). The segments are also divided internally by the septa. This is called true segmentation or metamerism.

The first segment is called peristomium. The mouth is present in this segment. A fleshy lobe called prostomium covers the mouth. The segmentation in the first few segments is visible externally without corresponding internal septa.

The clitellum is a prominent circular muscular band present in the 14th, 15th and 16th segments. It divides the body into pre-clitellar, clitellar and post-clitellar regions.

The female genital pore is a single aperture present mid-ventrally in the 14th segment. The male genital pores are a pair of openings found on the ventral surface of the 18th segment. Two pairs of genital papillae are present in 17th and 19th segments which helps the animal in copulation.

In the grooves of 5th-9th segments, four pairs of spermathecal pores are present ventro-laterally. These are connected to the sperm storing organ called spermathecae.

On the dorsal side minute pores are found called dorsal pores through which the coelomic fluid exudes out of the body. This fluid keeps the body surface moist.

There are numerous pores called nephridiopores present on the ventral surface of the body. These are the opening of the excretory organs called nephridia that expel out the nitrogenous waste from the body.

The last segment is called the anal segment and it bears the anus.

Anatomy
Body Wall
The body wall of earthworm has four layers, i.e., cuticle, epidermis, musculature and coelomic epithelium or parietal peritoneum.
a. It is a thin, transparent, non-cellular surface layer. The cuticle is secreted by the epidermis and is perforated by numerous minute pores.
b. It is the next layer after cuticle, made up of a single layer of columnar epithelium which contain secretory gland cells, i.e., basal cells, sensor or receptor cells, setigerous cells (seta forming cells), etc.c.

c.It is composed of an outer thin layer of circular muscle fibres and an inner thick layer of longitudinal muscle fibres. Contraction of circular muscles makes the body long and thin whereas, the contraction of longitudinal muscle fibres makes the body thick and short.

d. It is a thin, membrane like coelomic epithelium consisting of flattened squamous cells.It protects the internal organs and prevents excessive evaporation. The receptor cells play a vital sensory function. Setae and muscles help in locomotion.

The excretory matter is passed out through the nephridiopores present in the body wall.

Digestive System

A complete alimentary canal is present in the body cavity of earthworm beginning with the mouth in the first segment and ends with the anal opening situated in the last segment. The earthworm swallows the soil and the organic content of the soil is digested.

The various regions of earthworm's alimentary canal are following
(i) Buccal cavity l-3rd segments.
(ii) Pharynx 4th segment.
(iii) Oesophagus (food pipe) 5-7th segments.
(iv) Gizzard 8-9th segments. It helps in grinding the food.
(v) Stomach 10-14th segments. The stomach wall, contains calciferous glands to neutralise the humic acid in the soil.
(vi) Intestine 15th to the last segment where it opens out by anus.
(vii) Typhlosole Between 25-95th segments, there is a prominent infolding on the dorsal wall called the typhlosole. This enhances the area of absorption of the intestine of the digested food.

Respiration
The skin serves as the organ of respiration. It is thin, transparent and richly supplied with blood vessels. Respiration through the skin is called cutaneous respiration. Haemoglobin is found dissolved in the blood plasma.

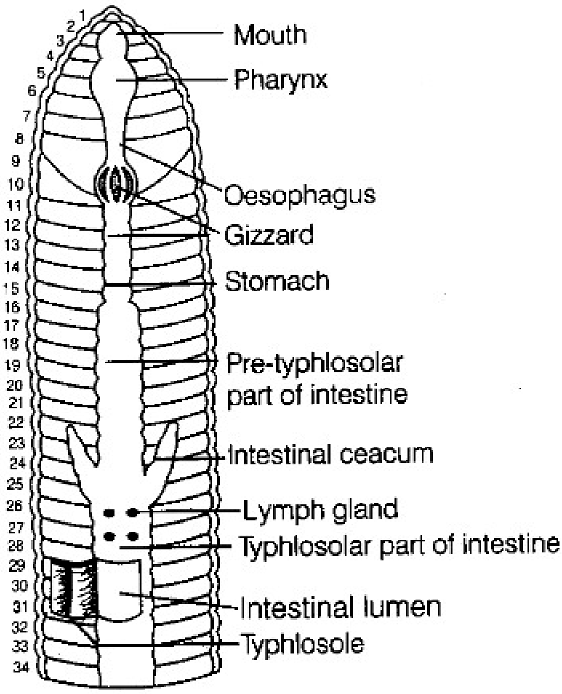


Fig. 7.22 Alimentary canal of an earthworm

Circulatory System

Pheretima exhibits closed type of blood vascular system, consisting of blood vessels, capillaries and heart. Due to closed circulatory system, blood is confined to the heart and blood vessels.

There are three main median longitudinal blood vessels namely a dorsal vessel (above the alimentary canal), ventral vessel (below the alimentary canal) and a sub-neural vessel (lying on the ventral side below the nerve cord). In the blood vessel, the blood flows from the posterior to the anterior end. In the ventral and subneural vessel, the flow of blood is from anterior to the posterior end.

There are four pairs of hearts, a pair of each lying in 7th, 9th, 12th and 13th segments. All the hearts have muscles and pulsatile walls to pump the blood into the ventral vessel by rhythmical contractions. The backward flow of the blood is prevented by the valves present in the heart.

(viii) Anus The undigested food is sent out through it.

Excretory System
The excretory organs occur as segmentally arranged coiled tubules called nephridia (sing, nephridium). They are offollowing three types.

These are present on both the sides of inter segmental septa of segment 15 to the last that opens into intestine. They discharge the waste matter into the gut via septal excretory ducts and supraintestinal ducts.

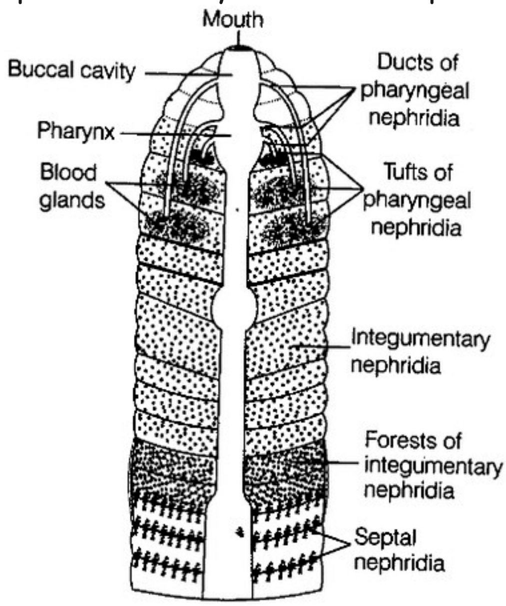


Fig. 7.24 Nephridial system in earthworm

Nervous System
Nervous system is basically represented by the ganglia which are arranged segment-wise on the ventral paired nerve cord.

The nerve cord in the anterior region (3rd and 4th segments) bifurcates laterally, encircling the pharynx and joins the cerebral ganglia dorsally to form a nerve ring. The cerebral ganglia along with other nerves in the ring integrate sensory input as well as command muscular responses of the body.

Reproductive System
Earthworm is a hermaphrodite (bisexual), i.e., testes and ovaries are present in the same individual. '

Mule Reproductive System
It possess two pairs of testes present in the 10th and 11th segments. The ducts of testes (vas deferentia) run upto the 18th segment, where they join the prostate

duct. Accessory glands are present, on the ventral side of the 17th and 19 th segments.

They open out by the fine ducts of genital papillae situated on the under surface of the segments 17th and 19th. Four pairs of sac-like structures called spermathecae are found one in each of the 6th to 9th segments. They receive and store spermatozoa during copulation.

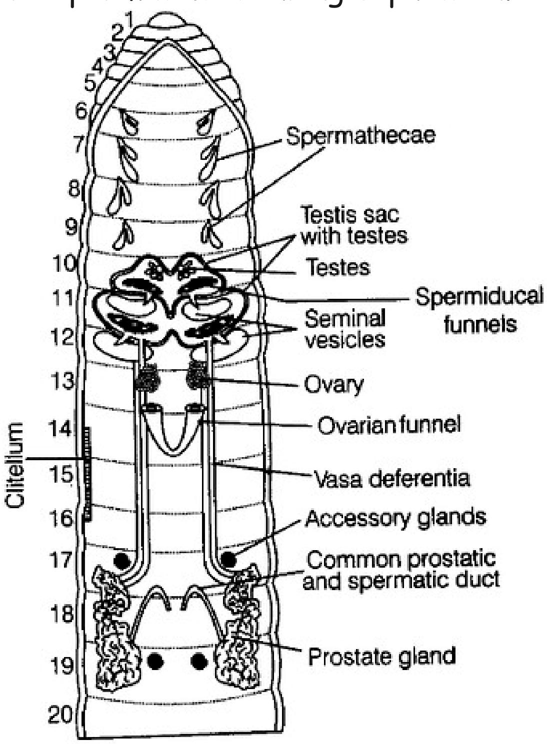


Fig. 7.25 Reproductive system of an earthworm

Femaie Reproductive System

One pair of ovaries is attached to the intersegmental septum between the 12th and 13th segments. Ovarian funnels are present beneath the ovaries which continue into oviduct. These ducts join together and open on the ventral side as a single female genital pore on the 14th segments.

Breeding and Fertilisation [An earthworm becomes sexually mature when it develops the clitellum. A mutual exchange of sperm occurs between the two worms during mating. Mature sperm, egg cells and nutritive fluid are deposited in the cocoons produced by the gland cells of the clitellum. Fertilisation and development occurs within the cocoons, which are deposited in the soil. The eggs are fertilised by the sperms within the cocoons, which then slips off the worm and is deposited in or on the soil.

The cocoons hold the worm's embryo. After about three weeks, each cocoon produces two to twenty baby worms. Earthworms development is direct, i.e., there is ' no larval stage and all earthworms lay eggs.

Economic Importance of Earthworms
Merits
Earthworms are useful in several ways for humans
(i) Earthworms make the soil porous by digging burrows in the soil. Hence, they are called friends of the fanners.
(ii) The nitrogenous wastes and other waste products of the earthworms form food for plants. This process of increasing fertility of soil by earthworms is called vermicomposting.
(iii) Earthworms are used as fish bait for catching fishes.
(iv) Some tribals in India use earthworms as medicine to cure jaundice, piles, diarrhoea, bladder stones, gout, etc.
(v) In some countries like China, Japan, Australia and Myanmar, earthworms are used as food.
(vi) The worms reduces both acidity and alkalinity of the soil and create optimum conditions for the plant growth.
(vii) Earthworms are eaten by frogs, birds, which are useful to man in some ways. Thus, they are an important part of food chain.
(viii) These are used in scientific studies and dissected in zoological laboratories for academic studies.

Demerits
Earthworms may also be harmful in many ways
(i) Earthworms may damage young and tender plants by eating them.
(ii) During rainy season, they make burrows and cause soil erosion.
(iii) They spoil the play grounds by digging burrows in them.
(iv) Some earthworms are intermediate hosts for some parasites such as tapeworm of chicken and lung nematode of pigs.

(v) The burrows of earthworms in the banks of irrigation channels sometimes cause leakage of the water.
Cockroaches are one of the common insects found in our house. They are brown or black bodied animals, although, bright yellow, red and green coloured cockroaches have also been reported in the tropical regions. In India, two species of cockroaches are found, i. e., Periplaneta americana and Blatta orientalis.

Locomotion
Cockroaches are cursorial insects, i.e., run very fast. They show double mode of locomotion-running and flying. The cockroach run on the tarsi of their legs. At a time, three legs are kept on the ground and the other three are carried forward. By repeating this step, the animal moves forward.
Cockroach flies by beating the hindlimbs with the help of special muscles. They are beaten up and down alternately.

Breeding
Cockroaches are unisexual. They show sexual dimorphism, i.e., male and female sexes can be seen externally. They are oviparous. The young cockroaches called nymphs resemble the adults in many features. The nymph undergo moulting or ecdysis in which the casting of older skin takes place. The nymph gradually become adults under the parental care.

The cockroaches are tropical and sub-tropical insects, but they have reached all parts of the world with trading ships. They are good enough to adapt to new habitats.

Habitat
Cockroaches inhabit the warm, dark and damp places. They are commonly found in underground drains, kitchens, restaurants, godowns, store houses, railway wagons, ships, etc., where food and moisture is available.

Habits
Cockroaches show some peculiar habits. They are nocturnal, i.e., come out of their hiding places at night to feed. These are omnivorous and eat all types of animals and vegetable v foods.

Morphology
The body of cockroaches is dorsoventrally flattened, elongated and bilaterally symmetrical. The adult cockroach is about 34-53 mm long with wings that extends beyond the tip of the abdomen in males.

The entire body of cockroach is covered by a hard chidnous exoskeleton (brown in colour) made of tough plates called sclerites. These are formed of chidn, a polysaccharide of acetoglucosamine molecule. , The exoskeleton protects the body and provides space for the attachment of muscles. The adjacent sclerites are joined together by thin, soft, flexible arthroidal membranes.

Head Antenna

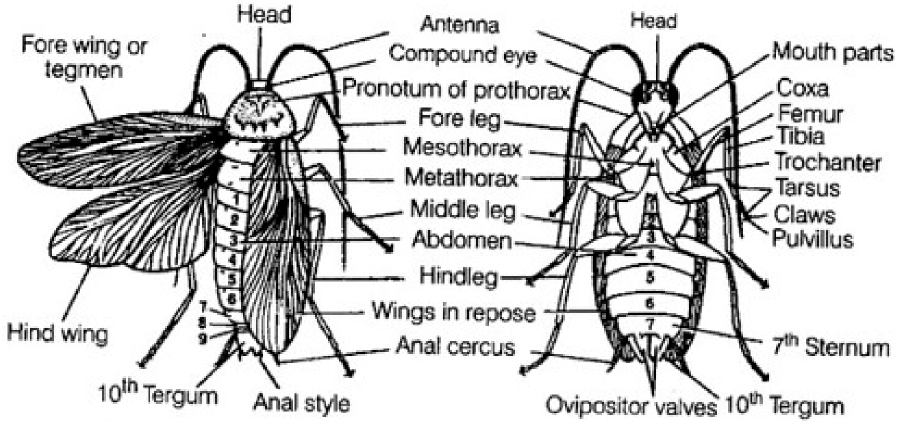


Fig. 7.26 Cockroah (a) Male cockroach (dorsal view) left wings raised (b) Female cockroach (venteral view)

The body of cockroach is segmented and divisible into three parts, i.e., head, thorax and abdomen.

Head

The head of cockroach is triangular in shape and lies anteriorly at right angles to the longitudinal body axis. It is formed by the fusion of six embryonic segments. It is flattened anteroposteriorly and movably articulates with the thorax by a short neck. It is covered by sclereites and bear sense organs, mouth parts and mouth. The sclerites of head are fused to form a compact head capsule called vertex.

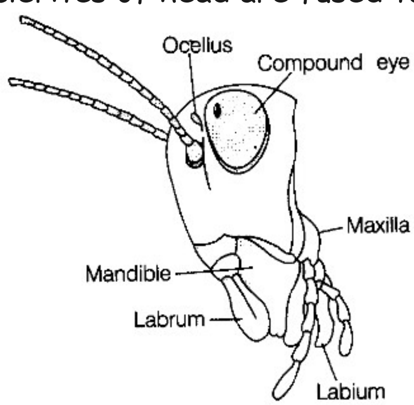


Fig. 7.27 Part of head region of Cockroach

Sense Organs

The sense organs in cockroach includes compound eyes, antenna and fenestrae or ocellar spots.

(i) Compound eyes are a pair of large, black, kidneyshaped organs situated dorsoventrally on the head, one on either side. Their surface is marked by a large number of hexagonal areas called facets. The eyes are the organs of sight.

(ii) Antenna are a pair of long, slender, jointed, tapering j filaments that articulates in the antennal sockets situated on the frons, close to the compound eyes. The antenna are organs of touch and smell. They can be moved in all directions to receive the stimuli. Antenna is made up of many segments called podomeres.

(iii) Fenestrae are a pair of small, whitish spots, each lying just above the inner to the antennal socket of its side, They are sensitive to light.

Mouth

It is a narrow opening that lies at the base of the pre-oral cavity. It is bounded by the mouth parts and leads into the pharynx. The mouth parts of cockroach are of biting and chewing type. They also help in swallowing. The mouth parts are attached to the head capsule.

The mouth parts include the following structures

(a) Labrum is also called upper lip that helps in holding food particles during feeding.

(b) Mandibles lie on the sides of the mouth just behind the labrum. The two mandibles work against each other in a horizontal plane to crush and cut the food into pieces.

(c) First maxillae are a pair of maxillae that lie beneath the mandibles, one on either side of the head.

(d) Second maxillae or labium is also called lower lip. It is a single structure, but it is formed by the fusion of a pair of second maxillae. It lies behind the mouth and forms a type of lower lip.

Neck

It is a slender, flexible (can move in all direction) tube articulating the head with the thorax. It is supported by a few ring-like sclerites.

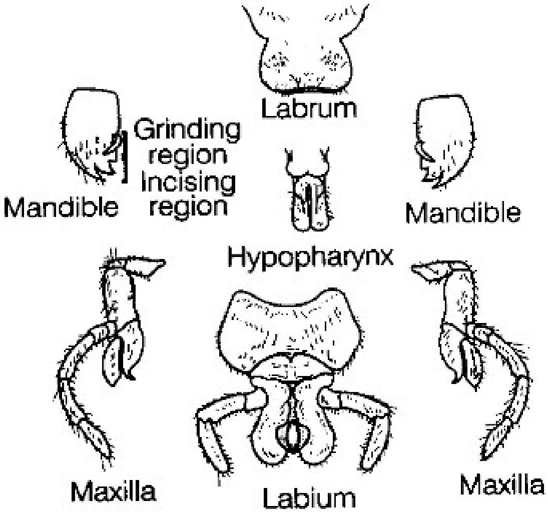


Fig. 7.28 Parts of Mouth of Cockroach

Thorax

The thorax forms the middle part of the body. It consists of three segments, the anterior prothorax, the middle mesothorax and the last metathorax. Each thoracic segment bears a pair of waiting legs. The thorax also contains spiracles for gas exchange.

Each thoracic segment is enclosed by four chitinous skeletal sclerites, a dorsal tergum, a ventral sternum and two lateral pleura. The tergum of the prothorax is called the protergum or pronotum.

The tergum of the mesothorax is called mesotergum or mesonotum. The tergum of metathorax is termed the metatergum or metanotum. The sterna of all the thoracic segments are largely covered by the legs.

The thorax contains three pairs of kgs and two pairs of wings

(a) Legs are jointed and a pair is present in each thoracic segment which are three in number. Based on the segment that bears them, legs are prothoracic, mesothoracic and metathoracic or simply prolegs, mesolegs and metalegs. They articulate with their respective segment between the sternum and the pleura.

(b) Wings These are paired structures, one on the mesothorax (forewings) and another on the metathorax (hindwings). The wings are movable folds of the integument that grow out from the region between the tergum and the pleura near

the anterior end of the segment.
Forewings called tegmina are opaque dark and leathery, used to cover the hindwings when they are at rest. While hindwing are transparent membranous and are used in flight.
They bear two thin sheets of cuticle with a framework of branching tubes, the veins or nervures.

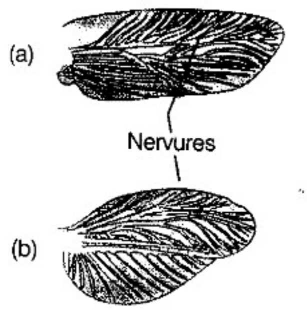


Fig. 7.29 Wings of cockroach
(a) Mesothoracic (b) Metathoracic wing

Abdomen
It is the posterior most and the largest part of the body. It is composed of ten segments in adults and eleven in the embryo. It is dorso-ventrally flattened, broader at the anterior end and narrow posteriorly.

Each abdominal segment bears sclerites. Certain segments have spiracles and stink glands. The terminal segments carry appendages and some apertures.

An abdominal sclerite is enclosed by four sclerites, a dorsal tergum, one ventral sternum and two lateral pleura.
There are ten terga. The 7th tergum covers the 8 th tergum in male and 8th and 9th terga in the female cockroach. The 10th tergum is large and notched in the middle. It projects backwards beyond the body. The abdomen bears 9th sterna, while the 10th one is absent. In male, all the nine sterna are visible and in female, only the first seven can be seen.

The abdomen in both male and female cockroaches comprises of 10th segments. In females, the 7th sternum is boat-shaped and together with 8th and 9th sterna forms a genital pouch.

In males, genital pouch lies at the hind end of the abdomen. It contains dorsal anus, ventral male genital pore and gonapophyses. The abdomen of female cockroach is broader than the male cockroach.

Male bears a pair of short thread like anal styles which are absent in females.

Abdominal Appendages
The abdomen bears small appendages at its hind end only. These appendages are a pair of anal cerci, (joined filamentous structures found in both sexes) a pair of anal styles and gonapophysis or external genitalia.

Apertures
The abdomen bears following three apertures
(a) Anus lies beneath the 10 th tergum between the two chitinous plates. These are called podical plates or paraprocts. They represent the remains of the eleventh segment.

(b) Genital aperture of the male cockroach lies just below the anus on one of the gonapophyses and that of female lies on the eighth sternum in the broad pouch.

(c) Abdominal spiracles are the eight pair structures. They are smaller than the thoracic spiracles.

(d) Stink glands A pair of stink gland is present between the 5th and 6th abdominal terga. These glands produce a secretion that gives a characteristic stinky smell.

Anatomy
The anatomical structure of different parts of cockroach body is described below

Body Wall
The body wall contains cuticle, epidermis and basement membrane. The cuticle is impermeable to water because of its thick, non-cellular surface layer. The epidermis consists of a single layer of columnar cells, enclosing some gland cells.

Body Cavity
Cockroaches are coelomate. But, true coelom occurs only in embryonic stage. In adults, it is found in small cavities only around the gonads. The body cavity is filled with haemolymph and is called haemocoel.

Endoskeleton
Certain processes of exoskeleton extend into the body and forms endoskeletal

elements. These provide attachment to the muscles and hence called apodemes. Abdomen of cockroach does not have endoskeletal elements.

Digestive System
The alimentary canal of cockroach is 6-7 cm in length.
It is divisible into following three parts
a. It is the anterior part of the alimentary canal. It is surrounded by the mouth parts. Food is crushed initially by mandibles and mixed with saliva and passed to the short tubular pharynx.

The pharynx inturn bends to join a narrow tubular passage called oesophagus, whichs passes through the neck and opens into a sac like structure called crop (a large pear shaped sac that stores the food).

From crop, the food enters a conical and muscular part called gizzard or proventriculus having, outer layer of thick circular muscles.

The gizzard has six large chitinous teeth. (Formed by inner culide layer) and fine bristles in ks grooves. Therefore, it is efficient in grinding of food particles and straining apparatus.

Gizzard marks the end of foregut. The whole foregut is lined by cuticle protecting the alimentary canal from rough food particles. Its posterior end projects in the form of a narrow tube into the midgut, called stomodael valve.

b. It is a short, narrow tube of uniform diameter, lined by endodermal glandular epithelium. A ring of 6-8 blind tubules called gastric or hepatic caeca present at the junction of foregut and midgut secrete digestive juices. The midgut is the major organ of digestion and absorption of digested food.
The posterior part of the midgut has a sphinter that keeps it closed.

c. It is broader than the midgut and is divisible into ileum, colon and rectum. Ileum is short and narrow bearing short spines. A ring of about 100-150 fine yellow coloured thread like filaments. Malpighian tubules is joined to the beginning of the ileum. Colon is a wide coiled tube which do not contain spines while, rectum is the last part of the hindgut.
The papillae present in the rectum absorb water and salts from the undigested

food. The rectum thus, opens outside by anus (which lies below the 10th tergum.)

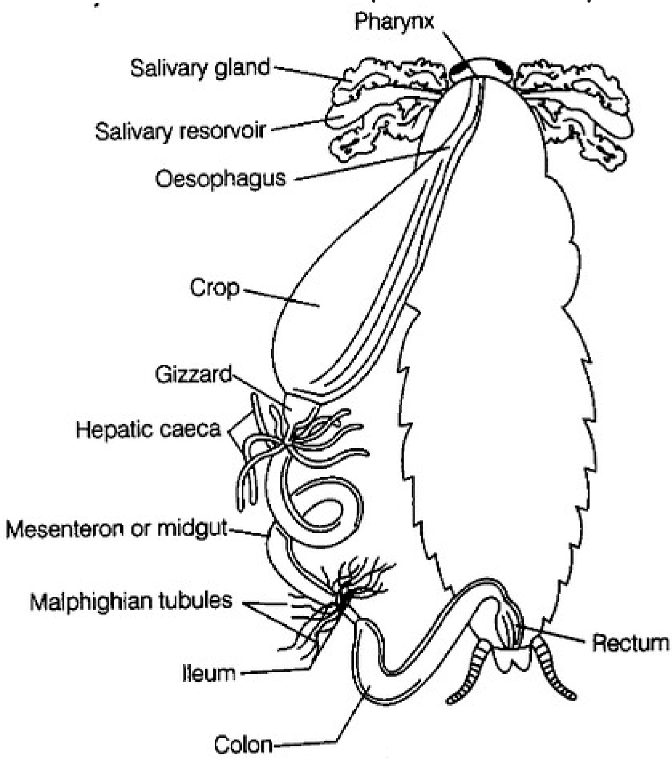


Fig. 7.30 Alimentary canal of a cockroach

Respiratory System

The respiratory system is comprised of a network of blind, glistering white air tubes called tracheae. The tracheae are connected to outside by 10 pairs of lateral apertures called spiracles. Two pairs of spiracles occur in thorax and eighth pairs are present in the abdomen.

During rest, some of the spiracles are open so, that the oxygen can diffuse continuously reaching the body fluid present in the terminal region of the tracheoles. Exchange of gases occurs between the living cells and the body fluid. Expansion of abdomen draws fresh air into the tracheal system through stigmata and its contraction expels foul air.

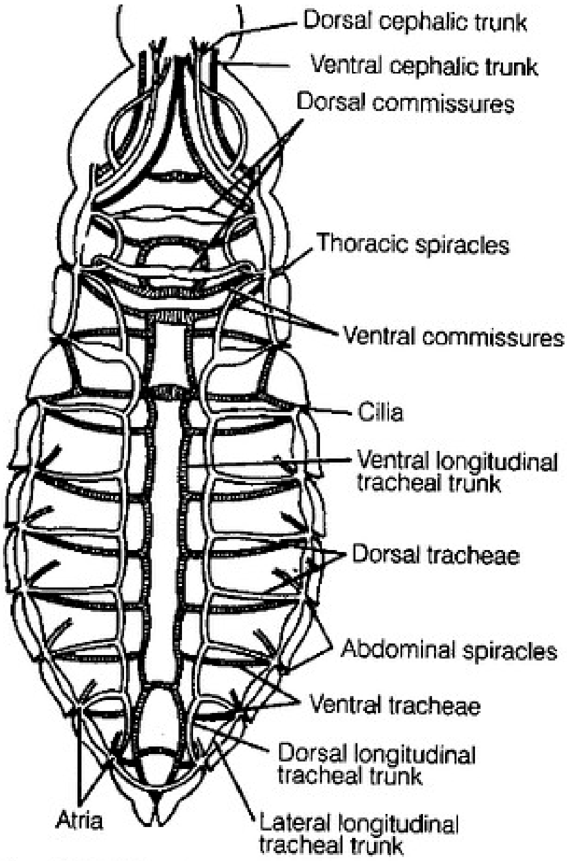


Fig. 7.31 Tracheal system of a cockroach (in ventral view)

Circulatory System

The circulatory system of cockroach is of open type. The blood vessels are poorly developed and blood flows freely in the body cavity which is called haemocoel. Visceral organs located in the haemocoel are bathed in blood (haemolymph).

It contains colourless plasma and corpuscles called haemocytes.

Each heart chamber opens into next chamber through a ventricular valve. Each chamber has a pair of incurrent pores called ostia (which possess valvular mechanism to pass the blood only from haemocoel to the heart chambers).

The heart chambers contract one after the other rapidly. This pushes the blood into the anterior aorta as well as a few lateral or excurrent arteries. From aorta, blood passes into head sinuses and then into perivisceral and perineural sinuses.

Excretory System
Cockroach is urecotelic, i.e., main excretory product of it is, uric acid. The. main excretory organs of cockroach are Malpighian tubules.

The tubules are lined by cuboidal, brush bordered, glandular cells that extract the nitrogenous waste matter from the haemolymph and discharge it into the ileum as uric acid.

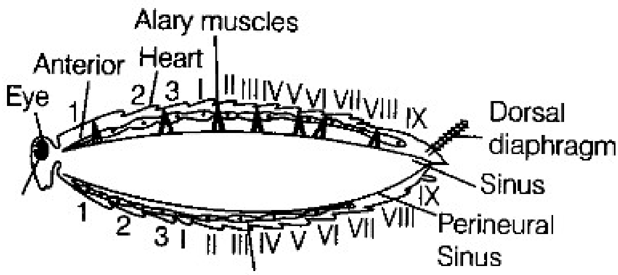


Fig. 7.32 Circulatory system of a cockroach

In rectum, the epithelial lining picks up most of the salts from urine and transport it into the haemolymph. Urine becomes nearly solidified and eliminates along with faces.
In addition to this, the fat body, nephrocytes and urecose glands also helps in excretion.

Nervous System
The nervous system of cockroach consists of a series of fused, segmentally arranged ganglia joined by paired longitudinal connectives.

Three ganglia lie in the thorax and six in the abdomen. The nervous system of cockroach is spread throughout the body. The head holds a bit of a nervous system while, the rest is situated along the ventral part of the body.

In the head region, the brain is represented by supra-oesophageal ganglion, which supplies nerves to antenna and compound eyes. Nerves arise from all the ganglia in the head, thorax and abdomen and innervate various parts in their respective regions.

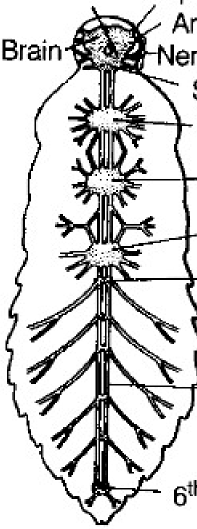


Fig. 7.33 Central and peripheral nervous system of a cockroach

The sense organs in cockroach, are antenna, eyes, maxillary palps, labial palps, anal cerci, etc. The compound eyes are situated at the dorsal surface of the head. Each eye consists of about 2000 hexagonal facets or ommatidia (each capable of forming an image in it).

Reproductive System

Cockroaches are dioecious animals, i.e., both the sexes have well developed reproductive organs.

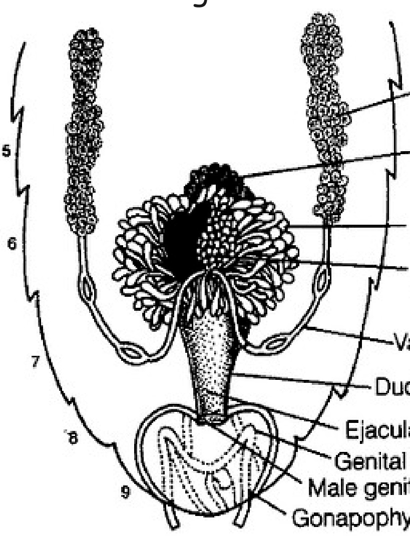


Fig. 7.34 Male reproductive organs of Cockroach (in dorsal view)

It consists of a pair of testes lying one on each lateral side in the 4th-6th abdominal segments. From each testis arises a thin vas deferens which opens into ejaculatory duct through seminal vesicle.

The ejaculatory duct opens into male genopore situated ventral to the anus. A characteristic mushroom shaped gland is present in the 6th-7th abdominal segments which functions as an accessory reproductive gland.

The external genitalia are represented by male gonapophysis or phallomere (chitinous asymmetrical structures surrounding the male gonopore). The sperms are surrounded in the seminal vesicles and are glued together in the form of bundles called spermatophores, which are discharged during copulation.

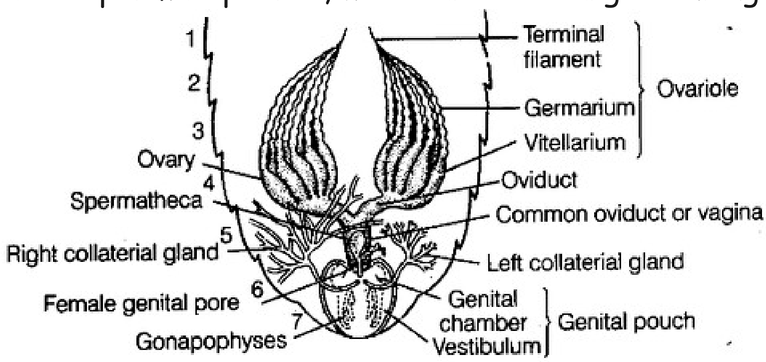


Fig. 7.35 Female reproductive organs of Cockroach (in dorsal view)

The male and female cockroaches come together by their posterior ends. The spermatophores are transferred to the genital chamber of the female. The sperms are liberated from the spermatophores and reaches the left spermatheca slowly.

The eggs come from both the ovaries alternately into the common oviduct and passes through the female genital pore into the genital chamber where they are fertilised by the sperms coming from the left spermatheca.

The secretion of collateral glands form the egg case of the ootheca (ploothecae). The fertilised eggs are encased in oothecae. Ootheca is a dark reddish to blackish-brown capsule, about 3/8" (8 mm) long.

The oothecae are dropped to a suitable surface, usually in a crack or crevice of relatively high humidity near a food source. On an average, females produce 9-10 oothecae, each containing 14-16 eggs.

Economic Importance of Cockroaches

Many species of cockroaches are wild and are of no economic importance. A few species thrive in and around human habitat. They damage and destroy household objects such as eatables, clothes, shoes, etc. They also carry harmful germs of diseases like diarrhoea, cholera, typhoid, tuberculosis, etc.

The contaminate food items with their smelly excreta. The animals like frogs, toads, lizards, birds and snakes, etc., eat cockroaches. Thus, they form the part of food chain. They are used in laboratories as experimental animals.

Distribution

Frogs are widespread in tropical and temperate regions. There are about 2600 species of frogs all over – the world. In India, four species of frogs are mainly found.

These are as follows

(i) Rana tigrina Most widely distributed found all over the world except in countries like Australia, New Zealand and Southern South America and largest species of India.

(ii) Rana cyanophlyctis Found in Rajasthan, UP and MP.

(iii) Rana malabaricus Common in Maharashtra.

(iv) Rana temporaria Common British frog.

Habitat and Habit

Rana tigrina is the most common frog found in India. It is also called bull frog because, of its large and loud call. It is found in or near freshwater, marshes, ditches, ponds and shallow water bodies. It has various reasons to lead amphibious (Amphi — two; bios — life) life, such as

(i) It can respire both through skin and lungs.

(ii) Frog breeds in water and spends its early life in water.

(iii) It is unable to drink water and absorbs it through the skin. Hence, it lives near the water.

(iv) It gets its food, from live insects, worms and spiders mosdy near the water.

The important habits of frog are described below

Feeding

Frog feeds on insects, worms and spiders, etc. It is. carnivorous. The prey is captured with the help of tongue.

ii. Locomotion

The frog usually shows three types of locomotion such as

(a) Swimming The body of frog is boat-shaped. During swimming, the hindlimbs are alternately folded and strengthened quickly. The backward stroke of hindlimbs pushes the body forward and thus, the animal swims.

(b) Leaping The frog moves on land by leaping. In leaping, the hindlimbs are folded and strengthened alternately. When the hindlimbs are extended, the frog's body is pushed forward and upward in the air.

(c) Walking During walking, each limb is lifted, swing forward and placed on-the ground again.

iii. Breeding

Frogs breed in rainy season. The male frog produce a high pitched croaking sound to attract the female. The male frog lacks copulatory organs. The sexual embrace in which the eggs and sperms are discharged in water is called amplexus or false copulation.

It is a characteristic of amphibians. The shedding of oocytes (eggs) by the female at the end of amplexus is called oviposition. The shedded oocytes and sperms remain embedded in a jelly like sac called as spawn. Fertilisation in frogs is exterrtal. The fertilised eggs develop into fish like tailed larvae, the tadpoles, which respire through gills. It feeds on plant matter (herbivore) and gradually develops into adult frog.

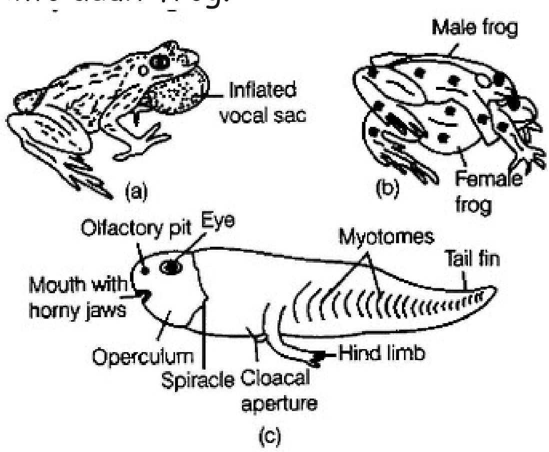


Fig. 7.36 (a) An inflated vocal sac of frog during breeding season (b) Frogs in amplexus (c) Tadpole of frog

iv. Hibernation and Aestivation

Frog is a cold-blooded (poikilothermic) animal. Its body temperature fluctuates according to its surrounding temperature. To avoid the adverse conditions of environment, frog burrows inside the soil and lies in a " state of rest or sleep during summers and winters.

The resting condition in winter is called hibernation or winter sleep and the condition of rest in summer is called aestivation or summer sleep.

v. Defences

Frogs escape from their enemies by several ways. If chased, they leap away to safe places or jump into water. They can also darken or lighten their green shade to blend with the background and thus prevent easy detection (camouflage). This protective colouration is called mimicry.

Morphology

The frog has an ovoid, streamlined and slighdy flattened body. It is about 10-15 cm long and shows bilateral symmetry, i.e., its right and left halves are mirror images of each other.

The skin of frog is naked, smooth, moist and slippery. A thin film of mucus is secreted by the cutaneous glands present in the skin. The body of frog is divisible into head and trunk. It is to be noted that neck and tail in frogs seem to be absent.

The head is triangular in shape with a blunt snout. It bears mouth, external nares, eyes, browspots and ear drums on the upper side and throat on the lower side.

The mouth extends along the entire border of the head. It is bounded by upper and lower jaws. (The lower jaw is toothless in frogs). The mouth gets open only during feeding.

At the top of anterior end, the head bears two small apertures called external nares. Air enters and leaves the body through the nares.

Eye

A little behind the nostrils, two large eyes are present, > situated along the sides. The eyes are spherical and protruded laterally.

Each eye has a thick upper and a thin lower eyelid. The upper part of the lower eyelid is modified into a transparent fold called nictitating membrane. This membrane protects the eye and is pulled over the eyeball when the frog is in water or under the mud and frog can see through it.

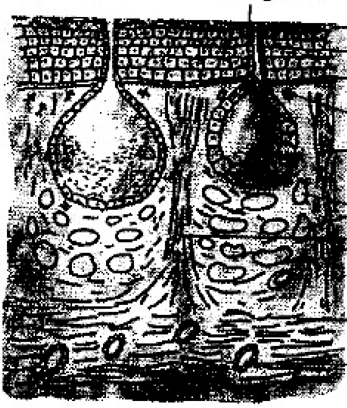


Fig. 7.37 VS of skin of frog

Coelom

The body cavity is a true coelom and large having two pans, a very small pericardial cavity around the heart which contains pericardial fluid and a very large pleuroperitoneal cavity around the other viscera that have coelomic fluid except the kidneys.

Both the fluids are watery, colourless and secreted by peritoneum.

Digestive System

The alimentary canal of frog is short because frogs are carnivores and hence, the length of intestine is reduced. It contains, mouth, buccopharyngeal cavity, oesophagus, stomach, small intestine, rectum and cloaca.
(a) Mouth It is present as a wide opening which opens into bucco-pharyngeal cavity. In frog teeth are not used for chewing but they prevent the escape of live food. Mouth opens into the buccal cavity that leads to oesophagus through pharynx.

(b) Oesophagus It is a narrow, short tube, which continues in large and distended stomach.

(c) Stomach It helps in converting the food into chyme and secretes gastric juice containing HC1 and proteolytic enzymes.

(d) Intestine It is a coiled structure continued with the stomach. The intestinal wall has several finger-like folds called villi and microvilli, projecting into its lumen to enhance the surface area of absorption for digested food. The first part of small intestine lying parallel to stomach is called duodenum. The duodenum is followed by ileum. Small intestine continues into a wider rectum which opens into a cloaca.

A litde behind and below the eye on each side of head, a circular patch of tightly stretched, dark skin is present. This is called tympanic membrane or tympanum or eardrum. It receives sound waves.

The floor of the head is occupied by a soft throat. In a male frog, there is a pair of bluish-wrinkled patches of skin called vocal sacs. They help in intensifying the croaking sounds.

Trunk
The trunk contains an anterior portion called thorax and a posterior larger portion called abdomen. A pair of forelimb and hindlimb is attached to the trunk. Each forelimb has an upper arm, a forearm and a hand. The hand has a wrist, a palm and four digits.

Each hindlimb consists of an upper thigh, a middle shank and a lower foot. The foot has an ankle, a sole and five digits. The digits are joined together by a fold of skin called web.

At the end of the trunk, between the hind legs, there is a circular aperture called cloacal aperture through which faeces, urine and gametes passes out.

Anatomy
The body cavity of frogs accomodate different organ systems such as digestive, circulatory, respiratory, nervous, excretory and reproductive systems with well-developed structures and functions.

Skin
The skin of frog consists of an outer epidermis and inner dermis. Epidermis is the outermost, non-vascular layer made up of stratified epithelium. The innermost layer of epidermis consists of Malpighian layer or stratum germinativum.

Dermis layer contains mucous glands and poison glands. The poison glands secrete poisonous fluid which protects the frogs from their enemies.

(e) Pulmonary respiration occurs by the lungs and is less frequent than the cutaneous and buccopharyngeal respiration. It occurs when more oxygen is required.

The urinary bladder opens into cloacal chamber through ureter. The cloaca opens externally by a cloacal aperture. This aperture serves both as an anus and as urinogenital pore.

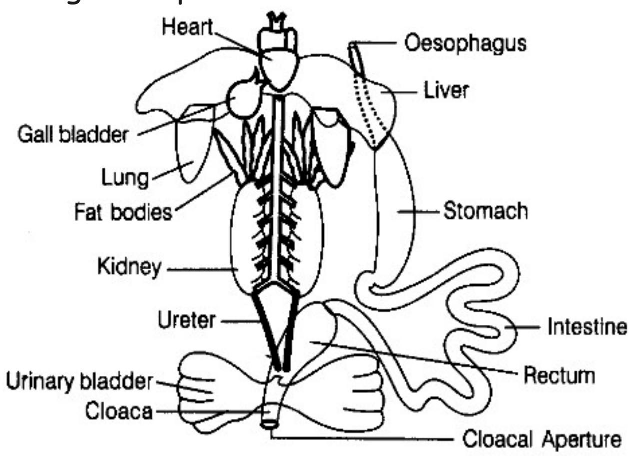


Fig. 7.38 Diagrammatic representation of internal organs of frog showing complete digestive system

The lungs are a pair of elongated, pink coloured sac-like structures present in the upper part of the trunk region (thorax). Air enters through the nostrils into the buccal cavity and then to lungs.
The exchange of gases occurs by diffusion in all the three modes of respiration.

Circulatory System
The circulatory system of frog is well developed and is of closed type. It also has a lymphatic system. The blood vascular system includes the heart, blood and blood vessels. The lymphatic system consists of lymph, lymph channels and lymph nodes.

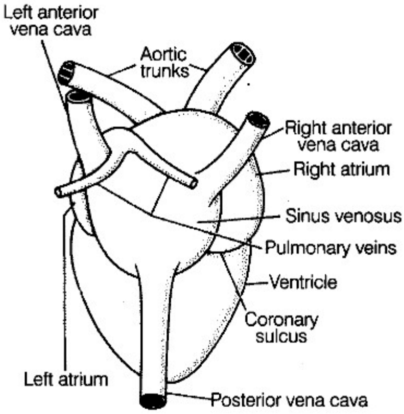


Fig. 7.39 Frog's heart (dorsal view)

The digestive glands include gastric glands, intestinal glands, liver and pancreas. The gastric glands secrete gastric juice and the intestinal glands secrete intestinal juice, which contains a number of digestive enzymes.
The liver produces bile which is temporarily stored in the gall bladder before being released info duodenum. Pancreas is an irregular, elongated gland that produces pancreatic juice containing several digestive enzymes.

Digestion of Food

The digestion of food takes place by the action of HCI and gastric juices secreted from the walls of stomach. The partially digested food called chyme is passed from stomach to the first part of the intestine, the duodenum.

The duodenum receives bile from gall bladder and pancreatic juice from the pancreas through a common bile duct. Bile emulsifies fat and pancreatic juices digest carbohydrates and proteins.

Final digestion occurs in the intestine. Digested food is absorbed by the numerous finger-like folds in the inner wall of intestine called villi and microvilli. The undigested solid waste moves into rectum and passes out through cloaca.

Respiratory System

Frogs respire by three modes of respiration
(a) Cutaneous respiration occurs through moist skin of the frog. Frogs respires only by the skin when under water or deep under the mltd.

(b) Buccopharyngeal respiration occurs when the animal is on land or partially immersed in water. It occurs by thin, vascular, moist lining of buccopharyngeal cavity.

It is a muscular structure situated in the upper part of body cavity. It has three chambers, i.e., two atria (sing, atrium) and one ventricle. The heart is covered by a membrane called pericardium.

There are two accessory chambers in the frog's heart, a tubular truncus arteriosus placed on the ventral side of the right auricle and a triangular sinus venosus present on the dorsal side of the heart.

Left anterior

Sinus venosus receives blood through the major veins called vena cava and opens into right auricle.

The left auricle receives oxygenated blood from the lungs by a common pulmonary vein. The auricles send their blood into ventricle where the blood gets mixed up. The ventricle opens into a sac-like conus arteriosus on the ventral side of the heart.

Nervous System

The system for control and coordination is highly evolved in the frog. It includes both nervous system and endocrine system. The nervous system of frogs consists of a central nervous system, a peripheral nervous system and an autonomic nervous system.

It includes brain and spinal cord. The brain is enclosed in a bony structure called cranium or brain box and the spinal cord lies inside the vertebral column. The brain is classified as forebrain, midbrain and hindbrain.

The forebrain consists of olfactory lobes, paired cerebral hemispheres and unpaired diencephalon.

The midbrain comprises paired optic lobes and the hindbrain comprises cerebellum and medulla oblongata. The medulla oblongata thus, passes out through the foramen magnum and continues into spinal cord present in the vertebral column.

It contain nerves arising from the central nervous system and extending into the organs of the body. Ten pairs of cranial nerves arises from the brain and nine pairs of spinal nerves supply the trunk and limb regions.

It consists of sympathetic nervous system of two ganglionic chains and parasympathetic nervous system of isolated ganglia in the viscera. The autonomic nervous system controls the functions of organs that are not under the voluntary control.

Sense Organs
The frogs have different types of sense organs such j as organs of touch (sensory papillae), taste (taste buds), smell (nasal epithelium), vision (eyes) and hearing (tympanum with internal ears), Out of these, eyes and ears are well organised structures and the rest are cellular aggregations around the nerve endings. Eyes in a frog are a pair of spherical structures situated in the orbit present in the skull. These are simple eyes.

External ear is absent in frogs and only tympanum can be seen externally. The ear is an organ of hearing as well as balancing (equilibrium).

Special venous connection between liver and intestine as well as the kidney and lower parts of the body are present in frogs. The former is called hepatic portal system and the latter is called renal portal system.

The blood vessels found in frogs are arteries, arterioles, veins, venules and blood capillaries.
Arteries carry blood from the heart to different body parts. Veins bring blood from different body parts to the heart.

Arteries further divide to form arterioles. The arterioles branch out to form capillaries, which further unite to form venules. The venules thus, join to form veins (which have valves to prevent backflow of the blood).

The blood is composed of plasma and blood cells. The blood cells are RBCs (Red Blood Cells) or erythrocytes, WBCs (White Blood Cells) or leucocytes and platelets. RBCs are nucleated and contain red coloured pigment namely haemoglobin.

The lymphatic system comprises of lymph vessels, lymphatic channels and lymph. Lymph is a mobile connective tissue filtered out from the blood through capillaries. It contains plasma and white corpuscles and lacks red blood cells,

Lymph in the body always flows in following direction Lymph capillaries —> Lymph sinus —> Lymph hearts —> Veins

Excretory System

The elimination of nitrogenous wastes is carried out by a well-developed excretory system.

The excretory system consists of a pair of kidneys, ureters, cloaca and urinary bladder. The kidneys are compact, dark red and bean like structure, situated little posterior in the body cavity on both sides of vertebral column.

Each kidney is composed of several structural and functional units called uriniferous tubules or nephrons. Each nephron is the structural and functional unit of kidney. The Bowman's capsule leads into a coiled, urinary tubule. The urinary tubule opens into transverse collecting tubules, which ultimately communicate with the ureter or urinogenital duct.

In females, the ureters and oviduct open separately into the cloaca. The thin-walled urinary bladder is present ventral to the rectum which also opens in the cloaca.
" The frog excretes urea and thus is a ureotelic animal. The excretory wastes are carried by blood into the kidney where these are separated and excreted.

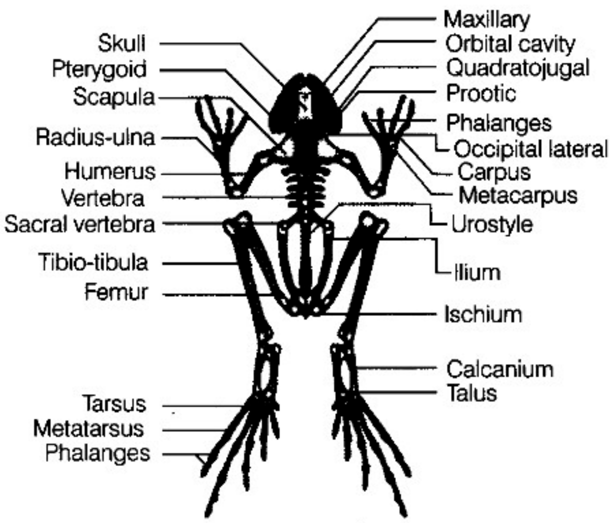


Fig. 7.40 Skeleton of frog

Endocrine System

The chemical coordination of various organs of the body is carried out by hormones, which are secreted by the endocrine glands. The prominent endocrine glands found in the frog are pituitary, thyroid, parathyroid, thymus, pineal body, pancreatic islets, adrenals and gonads.

Skeletal System

In frog exoskeleton is absent. The endoskeleton has two parts
(i) Axial skeleton that includes skull located in the head and vertebral column situated in the trunk. Appendicular skeleton includes limb bones in the arms and legs and girdles (pectoral and pelvic) that connects the limb bones with vertebral column. The skull consists of cranium, sense capsules and jaws. Vertebral column consists of 9 ring like vertebrae and a long urostyle. Each forelimb contains many bones namely, a humerus in the upper arm, a radioulna in the forearm, carpals in the wrist, metacarpals in the palm and phalanges in the fingers.

Each hindlimb consists of many bones namely, a femur in the thigh, a tibiofibula in the shank, tarsals in the ankle, metatarsals in the instep and phalanges in the toes.

Frogs have well organised male and female reproductive system. It shows sexual dimorphism.
Maxillary Orbital cavity Quadratojugal Prootic Phalanges Occipital lateral Carpus
Metacarpus Urostyle
Hiium
Ischium

Calcanium
Talus
It includes a pair of yellowish, ovoid testes which are found adhered to the upper part of the kidneys by a double fold of peritoneum called mesorchium.

From testes, 10-12 vas efferentia arises. They enter the kidneys on their side and open into Bidder's canal. The urinogenital duct comes out of the kidneys and opens into the cloaca. The cloaca is a small, median chamber that is used to pass faecal matter, urine and sperm to the exterior.

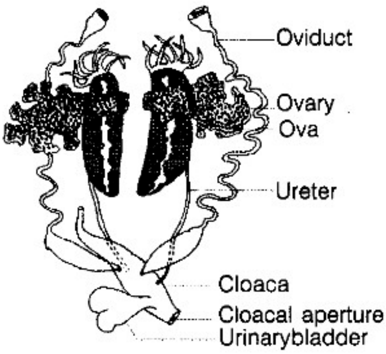


Fig. 7.41 Male reproductive system

It consists of a pair of ovaries situated near the kidneys and there is no functional connection with kidneys. A pair of long oviducts from ovaries opens into the cloaca. Ovaries release about 2500-3000 eggs at a time.

The eggs are released in water, so, the fertilisation is external. Development is indirect. A fish-like tailed larva called tadpole is formed. The tadpole undergoes metamorphosis to form an adult in about three months.

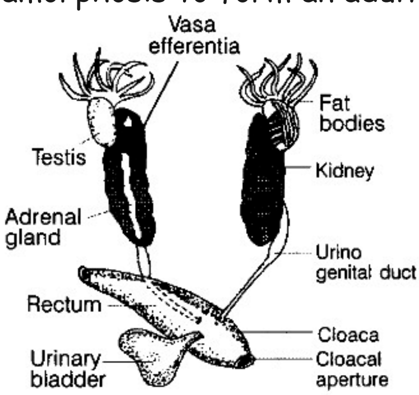


Fig. 7.42 Female reproductive system

Frog is a useful animal for humans in following ways
(i) It feeds on insects which destroy crops and frogs eat up mosquitoes, which are

the carriers of various diseases.
(ii) The muscles of legs of frogs are used as food in some parts of India and many other countries.
(iii) Baby frogs are used as fish baits, (any substance which is used to attract or catch fish).
(iv) Frogs are used for researches in medical science and pharmacology.
(v) They help to maintain ecological balance by forming an important part of food chain.

Structural Organisation in Animals Class 11 MCQs Questions with Answers

Question 1.
Blood corpuscles are formed in the
(a) Haversian canal
(b) endosteum
(c) red bone marrow
(d) pancreas
Answer
Answer: (c) red bone marrow

Question 2.
Which of the following is absent in female frog?
(a) Webbed feet
(b) Copulatory pads
(c) Tympanum
(d) All are present
Answer
Answer: (b) Copulatory pads
Explanation:
Copulatory pads are absent in female frog.
These are present on the first digit of the fore limbs.

Question 3.
Osteoblasts are found in
(a) blood
(b) muscle

(c) bone
(d) catrilage
Answer
Answer: (c) bone

Question 4.
Choose the incorrect statement.
(a) Vascular system of frog is closed type.
(b) Frogs have 4-chambered heart.
(c) During aestivation and hibernation, skin acts as respiratory organ.
(d) All the statements are correct.
Answer
Answer: (b) Frogs have 4-chambered heart.
Explanation:
Vascular system of frogs is closed and they have 3-chambered heart.

Question 5.
Which one of the four parts mentioned below is not part of a single uriniferous tubule ?
(a) Bowman scapsule
(b) Loop of Henle
(c) Distal convoluted tubule
(d) Collecting ducts
Answer
Answer: (d) Collecting ducts

Question 6.
Ciliated epithelium is present in
(a) fallopian tubes
(b) blood vessels
(c) mid brain
(d) none of the above
Answer
Answer: (a) fallopian tubes
Explanation:
Ciliated epithelium is present in inner surface of hollow organs like bronchioles ando fallopian tubes.

Question 7.
The vascular tissue of blood is made up of
(a) RBC
(b) plasma
(c) platelets
(d) all of the above
Answer
Answer: (d) all of the above

Question 8.
Which membrane protects the eyes of frog in water?
(a) Tympanum
(b) Skin
(c) Sebaceous
(d) Nictitating
Answer
Answer: (d) Nictitating
Explanation:
Frogs have nictitating membrane which protect their eyes in water.

Question 9.
Fats are richly found in
(a) alveolar tissue
(b) lymph glands
(c) adipose tissue
(d) liver cells
Answer
Answer: (c) adipose tissue

Question 10.
The main function of the skin of frog is
(a) the exchange of respiratory gases
(b) the storage of fat
(c) the storage of energy
(d) to convert light vitamin D
Answer
Answer: (a) the exchange of respiratory gases

Question 11.
The ciliated epithelium in our body may be found in
(a) trachea
(b) ureter
(c) bile duct
(d) intestines
Answer
Answer: (a) trachea

Question 12.
Which one of the following is a scent gland of mammals?
(a) Bartholin
(b) Anal
(c) Prostate
(d) Adrenal
Answer
Answer: (b) Anal

Question 13.
The characteristic of simple eqithelium is that
(a) the cells are loosely placed
(b) they are single – layered in thickness
(c) cells are tightly packed with no intercelluar spaces
(d) cells are generally ciliated
Answer
Answer: (b) they are single – layered in thickness

Question 14.
Spot the salivary gland in the following :
(a) sublingual
(b) adrenal
(c) Brunners
(d) lacrimal
Answer

Question 15.
Protein not found in the connective tissues is
(a) actin

(b) ossein
(c) collagen
(d) elastin
Answer
Answer: (a) actin

Question 16.
Tendons connect the following:
(a) bone to bone
(b) muscle to muscle
(c) cartilage to muscle
(d) bone to muscle
Answer

Question 17.
Frogs are beneficial to us because
(a) they protect crops.
(b) they links food web
(c) they are food to man.
(d) all of these
Answer
Answer: (d) all of these
Explanation:
Frogs are beneficial to man because they protect crops and eat insects.
They maintain ecological balance.
They link food chain and food web.
Muscular leg of frog is used as food by man.

Question 18.
Which membrane protects the eyes of frog in water?
(a) Tympanum
(b) Skin
(c) Sebaceous
(d) Nictitating
Answer
Answer: (d) Nictitating
Explanation:
Frogs have nictitating membrane which protect their eyes in water.

Question 19.
Which of the following helps in locomotion of earthworms?
(a) Clitellum
(b) Setae
(c) Intersegmental grooves
(d) Nephridiophores
Answer
Answer: (b) Setae
Explanation:
Setae helps in locomotion of earthworms.

Question 20.
Which is not a part of reproductive system of female cockroach?
(a) Phallic gland
(b) Vestibulum
(c) Gonapophyses
(d) Collaterial glands
Answer
Answer: (a) Phallic gland
Explanation:
Phallic gland is a part of male reproductive system of cockroach.
It helps in formation of spermatophores.

Solutions for Class 11 Biology Chapter 7 Structural Organisation in Animals:

NCRT TEXTBOOK QUESTIONS SOLVED

1. Answer in one word or one line.
(i) Give the common name of Periplaneta americana.
(ii) How many spermathecae are found in earthworm?
(iii) What is the position of ovaries in cockroach?
(iv) How many segments are present in the abdomen of cockroach?
(v) Where do you find Malpighian tubules?

Solution: (i) Cockroach.
(ii) Four pairs.
(iii) In cockroach two large ovaries, lie laterally in the 2nd – 6th abdominal segments'.
(iv) Abdomen of cockroach consists of 10 segments.
(v) Malpighian tubules are present at the junction of midgut and hindgut in cockroach.

2. What are the following and where do you find them in animal body?
(a) Chondrocytes
(b) Axons.
(c) Ciliated epithelium

Solution: (a) Chondrocytes – Chondrocytes are the only cells found in cartilage. They are present in spaces called lacunae and they produce and maintain the matrix of cartilage. Bending ability of cartilage is due to chondrocytes. Cartilage is present at tip of nose, pinna of ear, epiglottis etc.
(b) Axon – Axon is one of the processes of neuron, which is the structural and functional unit of nervous system. The part of cyton – n'here axon arises is axon hillock and axon ends in group of branches called terminal arborizations. It conducts impulses away from the cyton. Neurons (nerve cells) are present in brain and spinal cord.
(c) Ciliated epithelium – If the columnar or cuboidal cells bear cilia on their free surface they are called ciliated epithelium. Their function is to move particles or mucus in a specific direction over the epithelium. They are mainly present in the inner surface of hollow organs like bronchioles and Fallopian tube.

3. Draw a labelled diagram of the reproductive organs of an earthworm.

Solution:

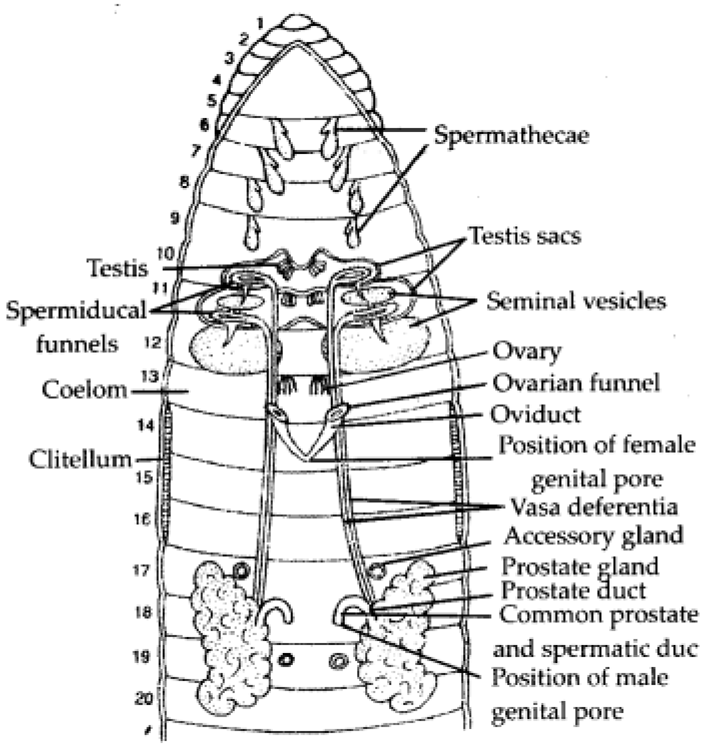


Fig.: Reproductive system of earthworm (Testis sacs are cut to show the internal structures of lodged organs).

4. Answer the following.

(i) What is the function of nephridia?

(ii) How many types of nephridia are found in earthworm based on their location?

Solution: (i) Nephridia are excretory organs of earthworm, which perform the function of excretion and osmoregulation. Nephridia regulate the volume and composition of the body fluids. A nephridium is a coiled tubular and microscopic structure which starts out as a funnel that collects excess fluid from coelomic chamber. The funnel connects with a tubular wastes through a pore to the surface in the body wall or into the digestive tube.

(ii) In earthworm, nephridia are present in all segments except the first two. There are three types of nephridia on the basis of their location:

(a) Septal nephridia, present on both the sides of intersegmental septa from segment 15 to the last that open into intestine.

(b) Integumentary nephridia, attached to lining of the body wall of segment 3 to the last that open on the body surface and

(c) Pharyngeal nephridia, present as three paired tufts in the 4th, 5th and 6th segments.

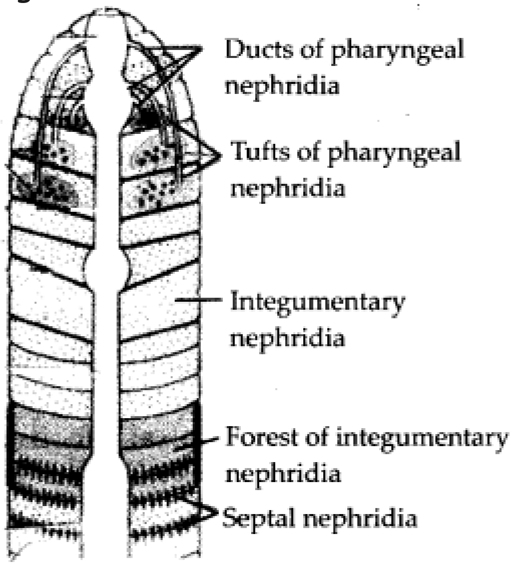


Fig.: Nephridial system of Earthworm

5. Draw a labelled diagram of alimentary canal of a cockroach.

Solution:

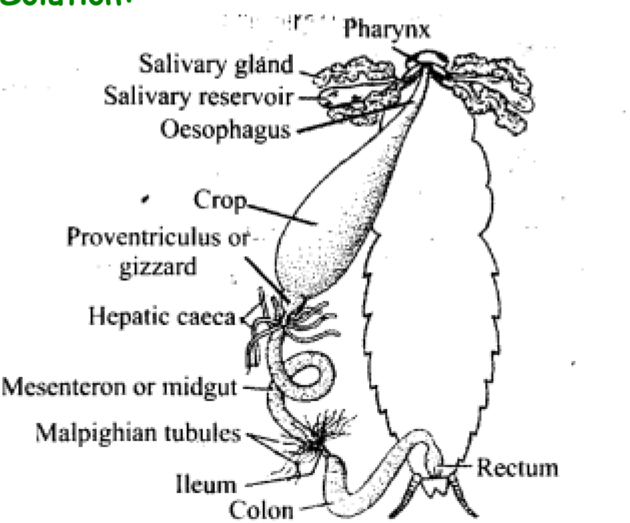


Fig.: Alimentary canal and salivary apparatus of cockroach.

6. What are the cellular components of blood?

Solution: Blood is a fluid connective tissue. It is composed of plasma (fluid) and blood cells (corpuscles). Cellular components of blood (blood corpuscles) constitute about 45% of blood volume.

Three types of blood cells are:

(i) Erythrocytes or red blood cells: They are most abundant blood cells. Normal RBC count is 5-5.5 million/mm^3 in males and 4.5-5 million/mm^3 in females) RBCs help in transport of gases and maintain blood pH.
(ii) Leucocytes or white blood cells: The normal WBC count is 5000-6000/mm^3 of blood. They are involved in immune response of body and act as soldiers and scavangers.
(iii) Thrombocytes or blood platelets: There are about 2,50,000 platelets/mm^3 of blood. They are involved in blood clotting.

7. Distinguish between the following:
(a) Prostomium and peristomium
(b) Septal nephridium and pharyngeal
Solution: (a) Differences between prostomium and peristomium are

	Prostomium	Peristomium
(i)	It is a fleshy lobe which projects from peristomium.	It is the first body segment in earthworm.

(ii)	It does not contain mouth.	It contains mouth.
(iii)	It serves as wedge to force open cracks in the soil in which the earthworm lives.	It does not happen in peristomium.
(iv)	It is sensory in function.	It is not sensory.

(b) Differences between septal and pharyngeal nephridia are:

	Septal nephridia	Pharyngeal nephridia
(i)	Occur in segment 15 onward.	Occur in segments 4, 5 and 6.
(ii)	Attached to the septa.	Lie on the sides of the gut.
(iii)	Their number varies from 80 to 100 per segment.	There are only 3 pairs of pharyngeal nephridia.
(iv)	Remove metabolic wastes from the blood and coelomic fluid.	Remove metabolic wastes from the blood only.
(v)	These nephridia discharge their excretory matter into lumen of alimentary canal.	The duct of nephridia of sixth segment open into buccal cavity while ducts of nephridia of fourth and fifth segment open into pharynx.

8. Mark the odd one in each series.
(a) Areolar tissue; blood; neuron; tendon
(b) RBC; WBC; platelets; cartilage

(c) Exocrine; endocrine; salivary gland; ligament
(d) Maxilla; mandible; labrum; antennae
(e) Protonema; mesothorax; metathorax; coxa.

Solution:

(a) Neuron: Areolar tissue, blood and tendon are connective tissues while neuron is a part a nervous tissue.
(b) Cartilage: RBC, WBC and platelets are parts of vascular connective tissue while cartilage is skeletal connective tissue.
(c) Ligament: Ligament is a connective tissue.
(d) Antennae: Maxilla, mandible and labrum are mouth parts of cockroach while antennae are sense organs.
(e) Protonema: Protonema is a filamentous juvenile stage in life cycle of Bryophytes, while mesothorax, metathorax and coxa are appendages of cockroach.

9. Match the terms in column I with those in column II.

Column I	Column II
(a) Compound epithelium	(i) Alimentry canal
(b) Compound eye	(ii) Cockroach
(c) Septal nephridia	(iii) Skin
(d) Open circulatory system	(iv) Mosaic vision
(e) Typhlosole	(v) Earthworm
(f) Osteocytes	(vi) Phallomere
(g) Genitalia	(vii) Bone

Solution: (a) – (iii), (b) – (iv), (c) – (v), (d) – (ii), (e) – (i), (f) – (vii), (g) – (vi)

10. Mention briefly about the circulatory system of earthworm.

Solution: Earthworm possesses a closed type of blood vascular system, as the blood flows through closed blood vessels. Blood is red in colour due to respiratory pigment haemoglobin. Prominent blood vessels in earthworm includes dorsal, ventral, sub- neural, lateral oesophageal and supra- oesophageal blood vessels. There are four pairs of tubular hearts, provided with valves. The anterior two pairs of hearts, known as lateral hearts lie in the 7th and 9th segments and connect the dorsal blood vessel with the ventral blood vessel. They receive blood from the dorsal blood vessel and convey it to the ventral blood vessel. The posterior two pairs of hearts are called latero-oesophageal hearts and are situated in the 12th and 13th segments. The latero-oesophageal hearts apart from connecting the dorsal and ventral blood vessels are also joined with the supra oesophageal blood vessel. Latero-oesophageal hearts carry blood from the dorsal vessel and the supra oesophageal vessel to the ventral blood vessel.Contractions keep blood circulating in one direction. Blood glands are present in the 4th, 5th and 6lh segments which produce blood cells and haemoglobin which is dissolved in blood plasma. Blood cells are phagocytic in nature.

11. Describe various types of epithelial tissues with the help of labelled diagrams.

Solution: Epithelial tissue is a tissue made of one or more layers of compactly arranged cells that covers external surface and internal free surface of body organs and which is underlined by a basement membrane. The various types of epithelial tissue along with the diagram are given below:
(i) Simple epithelium : It is composed of single layer of cells which rest on basement membrane. Simple epithelium generally occurs over secretory and absorptive surfaces and forms lining of body cavities, ducts and tubes. Simple epithelium is of several types.
(a) Squamous epithelium: It consists of single layer of flat cells, tightly linked together and have centrally located oval or spherical nucleus. It is also called pavement epithelium. It is found in walls of blood vessels, air sacs of lungs, and lining of eye lens.
(b) Cuboidal epithelium: Cells of cuboidal epithelium are as tall as wide, with centrally placed nucleus. Its main functions are secretion and absorption. It lines sweat gland, thyroid follicles, salivary glands. Brush bordered cuboidal epithelium, i.e., cells having microvilli on their free surface lines proximal part of uriniferous tubule, pancreatic duct, testis and ovary.
(c) Columnar epithelium: Cells are with basally located nucleus. It helps in secretion and absorption. It occurs in lining of intestine, stomach, gall bladder.
(d) Ciliated epithelium: Free surface of columnar and cuboidal cells are covered with cilia. Cilia help in moving fluids, particles, mucus, etc. in a specific direction. It occurs in the inner surface of Fallopian tubules, nasal passage, bronchioles.

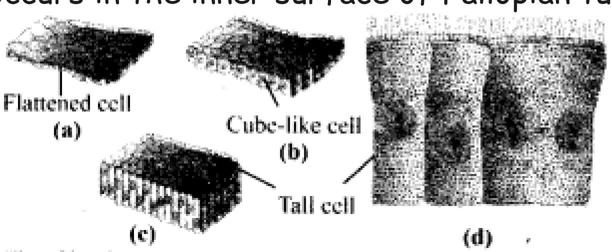


Fig.: Simple epithelium: (a) Squamous (b) Cuboidal (c) Columnar (d) Columnar cells bearing cilia.

(e) Pseudostratified epithelium: It consists of single layer of cells but some cells are shorter than others. Due to difference in size of cells, the epithelium appears

2-3 layered. Pseudostratified columnar epithelium occurs in urethra and parotid salivary gland. Pseudostratified columnar ciliated epithelium (only larger cells ciliated) occurs in lining layer of nasal' chambers, trachea and large bronchi. It helps in moving mucus and foreign particles.

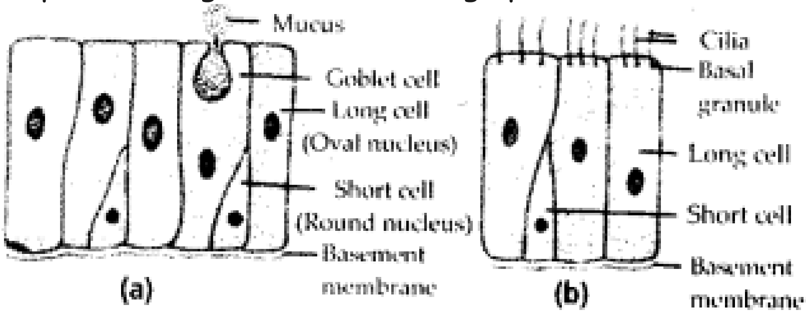


Fig.: Pseudostratified epithelium. **(a)** Columnar **(b)** Columnar ciliated

(ii) Compoundepithelium/stratifiedepithelium: It is multilayered epithelium where cells of only the lowermost or basal layer are in contact with basement membrane. It provides protection against mechanical and chemical stresses and has limited role in secretion and absorption. It covers dry surface of skin, moist surface of buccal cavity, pharynx, etc. Different types of compound epithelium are:
(a) Stratified squamous epithelium: The cells of outer layer are flattened and squamous while the inner layers are cuboidal cells. It is of two types: Non-keratinised lining oesophagus, pharynx, buccal cavity, cornea, vagina and anal canal and keratinised (comified): forming epidermis of skin, hair, horn and nail.

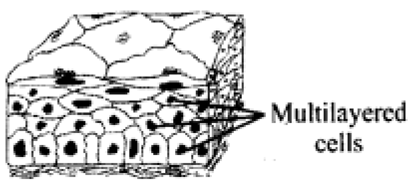


Fig.: Compound epithelium

(b) Stratified cuboidal epithelium: The outer layer of cuboidal cells and basal layer of columnar cells. It lines ducts of sweat glands, large salivary and pancreatic ducts.
(c) Stratified columnar epithelium: Both upper and basal layers are made of columnar cells, e.g., epiglottis covering, part of urethra.
(d) Stratified ciliated columnar epithelium: Outer layer consists of ciliated columnar cells and basal layer of columnar cells, e.g., larynx.
(iii) Transitional Epithelium: This is stratified epithelium which contains cuboidal or columnar shaped cells, which are thin and stretchable. No basement membrane is present as it would impede stretchability. It lines the inner surface of renal calyces, urinary bladder, ureter. Because of its t distribution, it is also called urothelium.

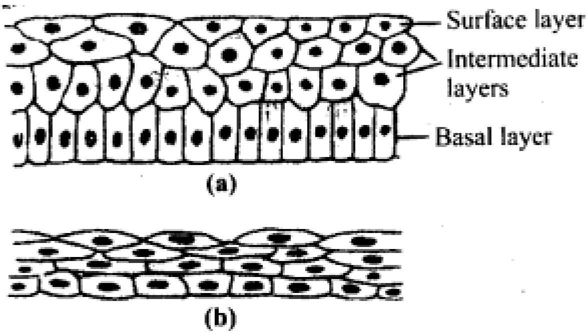


Fig.: Transitional epithelium,
(a) relaxed (= unstretched) (b) stretched.

(iv) Glandular epithelium: It consists of specialised epithelial cells which synthesise intracellular macromolecules (protein in pancreas, lipids in adrenal glands, glycoprotein in salivary glands and all the three in mammary glands) and pour out the same in the form of a useful fluid secretion which is different from blood or any other extracellular fluid. Glands can be unicellular or multicellular on the basis of number of cells.
(a) Unicellular glands: Single-celled, e.g., goblet (mucous) cells of respiratory tract and alimentary canal.
(b) Multicellular glands: Consist of cluster of cells, e.g., Salivary glands.

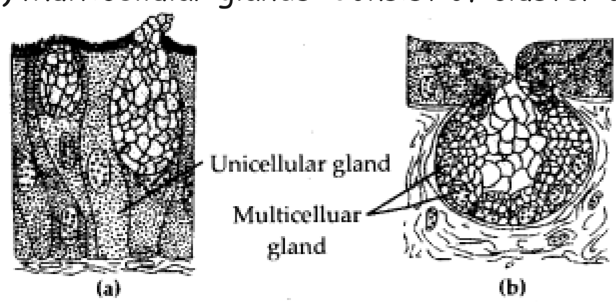


Fig.: Glandular epithelium : (a) Unicellular (b) Mulficellular

On the basis of presence or absence of duct glands can be:
(a) Exocrine glands : These glands pour their secretion through a duct. They secrete milk, saliva, mucus, earwax. e.g., goblet cells, salivary glands, tear glands, gastric glands, intestinal glands.
(b) Endocrine glands: They are ductless glands, which pour their secretions into blood or lymph for reaching the target region. Their secretion is called hormone e.g., pituitary gland, thyroid gland, parathyroid glands, adrenal glands.
(c) Heterocrine glands: Both exocrine and endocrine, e.g., pancreas.
On basis of mode of secretion glands can be:
(a) Merocrine: Secretion is discharged
through diffusion, e g., goblet cells, sweat glands.
(b) Apocrine glands: Glandular secretion accumulates in the terminal part of the

cell which is pinched off, e.g., mammary glands.
(c) Holocrine glands : The cell filled with secretory product disintegrates during discharge of the product, e.g., sebaceous gland.
(v) Modified epithelium : It is of following types:
(a) Germinal epithelium (generally cuboidal, produces gametes), (b) Glandular epithelium (columnar or cuboidal secretes chemicals and mucus), (c) Sensory epithelium or neuroepithelium. Epithelial cells having sensory hair on free surface and connected with nerve fibres on the other surface (generally columnar, receives and conveys stimuli), e.g, nasal epithelium, taste buds, retina, sensory spots of internal ear. (d) Pigmented epithelium – The cells possess melanin granules, e.g, retinal layer in contact with choroid of eye.

12. Distinguish between
(a) Simple epithelium and compound epithelium.
(b) Cardiac muscle and striated muscle.
(c) Dense regular and dense irregular connective tissues.
(d) Adipose and blood tissue.
(e) Simple gland and compound gland.
Solution:
(a) Differences between simple and compound epithelium are as follows:

	Simple epithelium	Compound epithelium
(i)	It is composed of a single layer of cells.	It is composed of two or more layers of cells.
(ii)	All the cells rest on the basement membrane.	Only cells of the deepest layer rest on the basement membrane.
(iii)	It functions as lining of body cavities, ducts and tubules. Main functions are secretion and absorption.	It provides protection against mechanical and chemical stresses.

(b) Differences between cardiac and striated muscles are as follows:

	Cardiac muscle	Striated muscle
(i)	It is present in the wall of the heart, pulmonary veins and superior vena cava.	It is present in the limbs, body walls, tongue, pharynx and beginning of oesophagus.
(ii)	Fibres are branched and uninucleate.	Fibres are unbranched and multinucleate.
(iii)	Oblique bridges and intercalated discs present.	No oblique bridges and intercalated discs.
(iv)	Nerve supply from the brain and autonomic nervous system.	Nerve supply from central nervous system.
(v)	They never get fatigued.	They soon get fatigued.
(vi)	These are involuntary.	These are voluntary.

(c) Differences between dense regular and dense irregular connective tissues are as follows:

	Dense regular connective tissue	Dense irregular connective tissue
(i)	In this tissue, the collagen fibres are present in rows between many parallel bundles of fibres.	This tissue has fibroblasts and many fibres (mostly collagen) that are oriented differently.
(ii)	It occurs in dermis of skin, walls of blood vessels, lungs, bronchioles. *E.g.*, Tendon and ligament.	This tissue is present in the skin.

(d) Differences between adipose tissue and blood tissue are as follows:

	Adipose tissue	Blood tissue
(i)	Adipose tissue is a type of loose connective tissue located mainly beneath the skin.	Blood is a fluid connective tissue containing plasma, red blood cells (RBCs), white blood cells (WBCs) and platelets.
(ii)	The cells of this tissue are specialised to store fats. The excess of nutrients which are not used immediately are converted into fats and are stored in this tissue.	It is the main circulating fluid that helps in the transport of various substances.

(e) Differences between simple gland and compound gland are as follows:

Simple gland	Compound gland
In simple glands duct is unbranched. They are further differentiated into unbranched and branched depending upon the condition of secretory part.	In compound gland both the duct and secretory part are branched. Further differentiation is made on the basis of shape of secretory part.

13. Draw a neat diagram of digestive system of frog.

Solution:

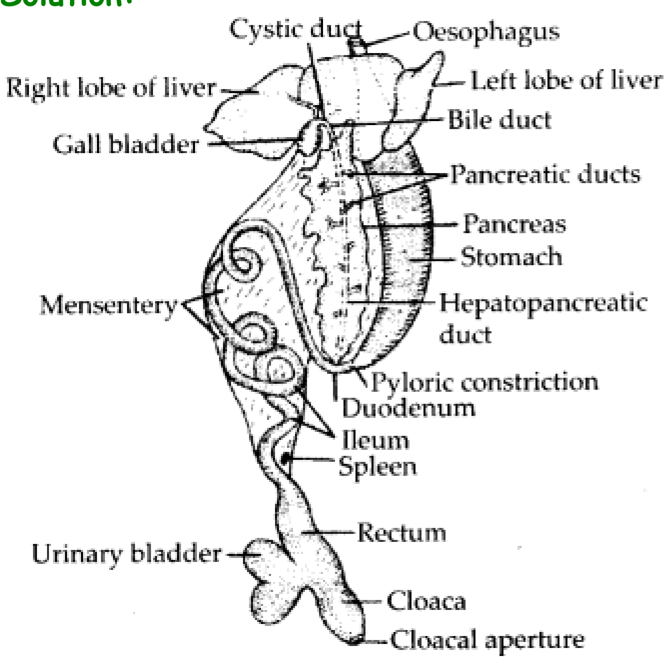


Fig.: Alimentary canal of frog.

14. Mention the function of the following:
(a) Ureters in frog
(b) Malpighian tubules
(c) Body wall in earthworm.

Solution:

(a) Ureters in frog: Ureter is a transparent duct which arise from outer portion of kidney. In the "male frogs, ureter acts as urinogenital duct which runs backwards from kidneys and opens into the cloaca. It carries both urine and spermatozoa from kidney to the cloaca. In female, ureter conducts only urine from kidneys to the cloaca.

(b) Malpighian tubules: Malpighian tubules are excretory organs present in cockroach. These are present at junction of mid gut and hindgut. These are fine, long, unbranched, yellowish and blind tubules and are 100-150 in number. They help in the removal of excretory products from haemolymph.

(c) Body wall in earthworm: It consists of cuticle, epidermis, muscular layer and parietal peritoneum.

(i) It maintains the characteristic shape of' the body.

(ii) It protects the internal organs.

(iii) The cuticle prevents excessive evaporation.

(iv) It serves as an ideal respiratory organ.

(v) The receptor cells play a vital sensory function.

(vi) The albumen helps in the formation of cocoon. It also serves as a food for the developing earthworm inside the cocoon.

(vii) Setae and muscles are responsible for locomotion.

(viii) Excretory matter is passed out through nephridiopores.

Cell The Unit of Life Class 5 Notes Biology Chapter 8

Topic 1 Cell :An Overview

An organism consist of one or more cells, accordingly there are two types of organisms, i.e., unicellular (composed of single cell) and multi cellular (composed of many cells).

Cell Theory

The cell theory was formulated by two German Scientists, Matthias Schneider and Theodore Schwinn independently. Schneider (1838) examined a large variety of plant tissues and observed that all plants are composed of different kinds of cells. At about the same time, Schwinn (1839), closely studied different types of animal cells and found that the animal cell had a very thin outer layer known as plasma membrane.

He also concluded, from his studies based on plant tissues that animal cells differ from plant cells in lacking cell wall.

Objections to Cell Theory

Cell theory failed to explain how and from where the new cells were formed. All these observations lead to a major expansion of cell theory that was expressed by Rudolf Virchow in 1855 modified the hypothesis of Schneider and Schwinn and explained in his statement that cells divide and new cells are formed from pre-existing cells, i.e., Omnis cellula-e-cellula.

Thus, the cell theory states that

Outer membrane, the boundary of the cell, which provides protection to the cell and controls the exchange of ions, molecules and other components in and out of the cell.

The outer membrane of a cell contains cell wall (only in plant cells) and plasma membrane.

Details of the above mentioned cell components and organelles is given later in the chapter in the second topic.
Microscopes allow us to study the structure of cells, two types are l commonly used, i.e., light microscopes and electron microscopes, Cells are divided into compartments that help segregate functions, leading to more efficient performance; human cells consist of two l major compartments, i.e., the cytoplasmic and nuclear.

Size of a Cell
The cells exhibit an endless variation in size, life span and cellular activities, e.g., Mycoplasma (smallest cell) or PPLOs (Pleuro-Pneumonia Like Organisms) is only 0.3 Jim in length and bacteria are approx. 3-5 Jim in size.
An ostrich egg, which is known to be the largest isolated single cell measures about 170 X 135 mm. Human Red Blood Cells (RBCs) are about 7 Jim in diameter and the nerve cell of human being is the longest cell having length of 90-100 cm.

Shape of a Cell
The cells also vary in their shapes. They may be polygonal, disc-like amoeboid, thread-like, cuboid or irregular. The cell shape is always related and vary with the function they perform.

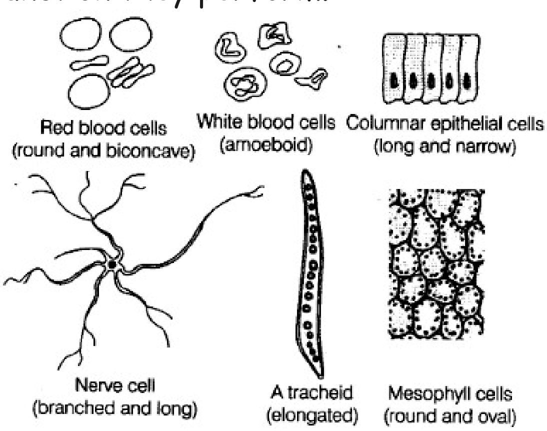


Fig. 8.1 Diagram showing different shapes of the cells

(i) All living organisms are composed of cells and their products.

(ii) All cells arise from pre-existing cells.
(iii) Cells show similarity in chemical composition and metabolic activities.
(iv) Cells are the structural and functional unit of living organism.

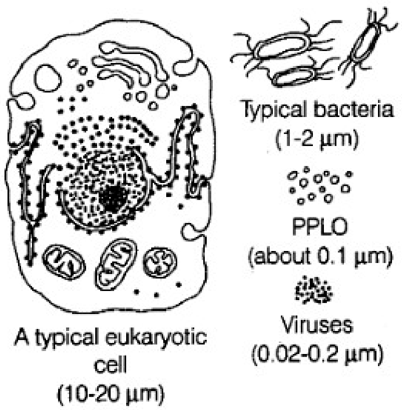


Fig. 8.2 Diagram showing comparison of eukaryotic cell with other organisms

Cell Envelope and Its Modifications

Cell envelope is the outermost covering of protoplasm of the bacterial cell. It is known to protect the cell from mechanical shocks and injuries.

It is composed of following three layers, which perform specialisedfunction
i- Glycocalyx (Mucilage Sheath)
It is the outermost layer, made up of macromolecules that gives sticky character to the cell. Glycocalyx differs in composition and thickness among different bacteria. It could be in the form of loose mucilaginous sheath called slime layer or thick and tough covering called capsule.
Function help in resisting phagocytosis.

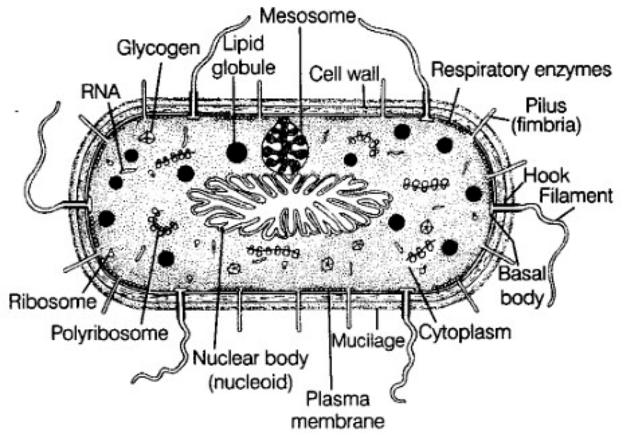


Fig. 8.3 Diagrammatic representation of a typical bacterial cell

Cell Wall

It is present just below the glycocalyx made up of peptidoglycan or murein in all eubacteria and cyanobacteria. It is a rigid and solid covering that gives shape and strong structural support to the cell.

Cell wall performs the following functions

(a) It helps in preventing cell from bursting or collapsing.
(b) It allows the material to pass in and out of the cell.
(c) It wards off the attack of pathogens like viruses, bacteria, fungi, protozoans.
(d) Provides mechanical support to the cell against gravity.

Gram Positive and Gram Negative Bacteria

According to Christian Gram (1884) various types of reactions are shown by the cell walls of different bacteria. Thus, on the basis of the differences in the cell wall and the response to the staining procedure developed by Gram, bacteria are classified into following two types

(i) Gram positive (+ve) bacteria are those that take up the Gram stain and retain blue or purple colour, e.g., Bacillus subtilis, Clostridium, etc.

(ii) Gram negative (-ve) bacteria are those that do not take up Gram stain and loose the blue or purple icolour, e.g., Escherichia coli, (E.coli), Acetobacter, etc.

Plasma Membrane

It is the innermost layer of the cell envelope. It is semi-permeable in nature and is responsible for the interaction of the cell with the outside environment.

It performs a number of functions as follows
(a) It helps in the regulation of the exchange of specific materials between the cytoplasm and extracellular medium.
(b) Selectively permits particular molecules to pass and prevents others.
(c) Prevents loss of components from the cells through leakage.

Note:

- The plasma membrane is vital to cellular homeostasis and therefore, the health and welfare of all living organisms.
- Molecules move through membranes either passively, flowing down concentration gradients or actively, being pumped in or out of cells.
- Membrane in prokaryotes is . structurally similar to eukaryotes.

Membranous Structures
Prokaryotic cells lack the complex membrane bound organelles (such as chloroplast, mitochondria, etc). However, some other special membranous structures are found in them (i.e., mesosomes and chromatophores).

Mesosomes
These are formed by the extensions of the plasma membrane into the cell in the form of vesicles, tubules and lamellae.

Mesosomes are equal to mitochondria in eukaryotes, as these structures participate in aerobic cellular respiration in prokaryotes.

Mesosomes perform the following junctions in bacterium
(a) Helps in respiration, cellular secretion, etc.
(b) Helps in increasing the enzymatic content and surface area of the plasma membrane.
(c) Helps in the formation of a cell wall.
(d) Helps in the replication of DNA and distribution of genetic material to daughter cells during fission.

Chromatophores
They are another membranous structures present in some prokaryotes like cyanobacteria, etc.

They are internal membrane systems of photosynthetic forms, which possess photosynthetic pigments. These pigments are light reflecting.

Flagella

Bacteria can be motile or non-motile. Thus, motile bacteria possess one or more thread-like appendages extending from their cell wall called flagella (sing, flagellum). Bacteria are also classified according to the number and arrangement of flagellum in them.

Each flagellum is about 1-7 nm long covered by a protein coat.
The bacterial flagellum is differentiated into the following three parts
(i) Filament, the longest portion, extending from the cell surface to the-outside. It is made up of protein called flagellin.
(ii) Hook, a curved and tubular structure made up of protein subunits.

Pili Fimbriae

They occur only in Gram negative bacteria. They occur in both Gram positive and Gram negative bacteria.
They are longer and broder. They are shorter and narrower.
They are responsible for sex duction (conjugation) in bacteria. They are specialised for attachment of bacteria to its host (e.g., Bacteria, Salmonella typhimurium, Neisseria gonorrhoea, etc).
They are tubular structures. They are bristle-like solid structures.
(iii) Basal body, the most complex part of flagellum.

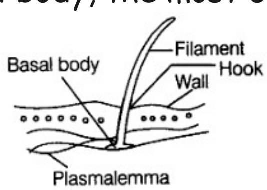


Fig. 8.4 Bacterial flagellum showing different parts

They help in locomotion i.e., movement from one place to another.

Pili and Fimbriae

These are also surface structures, but does not play any role in locomotion of bacteria. The pili are the elongated, tubular structues made of a special protein called pilin and fimbriae are the small bristle-like fibres coming out of the cell.

The pili helps in forming conjugation tube during transfer of genetic material between donor and recipient cell. While, the fimbaiae help the bacteria to attach to solid surfaces.

Differences between Pili and Fimbriae

Pili	Fimbriae
They occur only in Gram negative bacteria.	They occur in both Gram positive and Gram negative bacteria.
They are longer and broder.	They are shorter and narrower.
They are responsible for sex duction (conjugation) in bacteria.	They are specialised for attachment of bacteria to its host (*e.g.*, Bacteria, *Salmonella typhimurium*, *Neisseria gonorrhoea*, etc).
They are tubular structures.	They are bristle-like solid structures.

Ribosomes and Inclusion Bodies

Cytoplasm in prokaryotes appear granular, due to the presence of following structures:

i. Ribosomes

Like eukaryotes, ribosomes are also found in prokaryotes and serves a common function, i.e., acts as a site of protein synthesis. Ribosomes are small, but are complex both in structure and chemical composition. They are about 15-20 nm in size.

In prokaryotes, ribosomes are found in association with the plasma membrane of the cell (as it lack endoplasmic reticulum) in the cytoplasmic matrix. The prokaryotic ribosomes are of 70S type.

It has following two sub-units

(a) Smaller subunit (30S)

(b) Larger subunit (50S)

Ribosomes generally occur in helical groups called polysome or polyribosomes. In each polysome 4-8 ribosomes are attached to a single strand of wRNA. The ribosomes of a polysome helps in the translation (mechanisms to synthesise several copies of the same protein) of wzRNA into protein.

ii. Inclusion Bodies

They are non-living structures present in the cytoplasm and not bounded by any membrane system. They may either lie free in the cytoplasm (e.g., Cyanophycean granules, glycogen granules) or may be covered by 2-4 nm thick, non-protein membrane (e.g., Gas vacuoles, sulphur granules, etc).

Note:

- Gas vacuoles are gas storing vacuoles that do not have any covering of their own. They are found in cyanobacteria (blue-green algae), purple and green photosynthetic bacteria.
- These are named so, because they are permeable to atmospheric gases but not to water.

Topic 2 Eukaryotic Cell

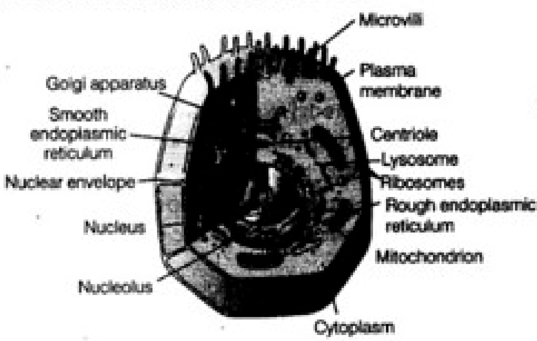
A cell which has a well organised nucleus with a nuclear envelope and several membrane bound organelles is called eukaryotic cell.

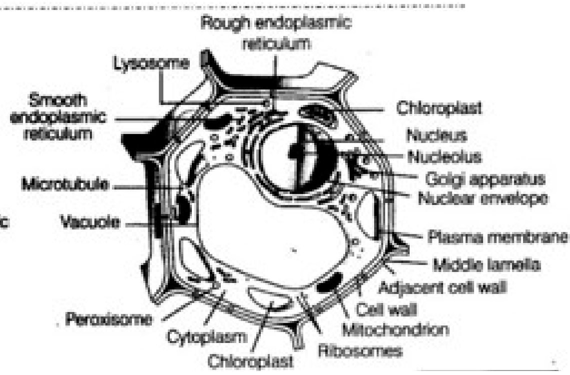
Internal organisation of eukaryotic cells is more advanced and elaborate, than the prokaryotic cells. All eukaryotic cells are not identical. Except monerans, eukaryotic organisation is seen in all the protists, plants, fungi and animals. Eukaryotic cell is larger than the prokaryotic cell (i.e., around 10-100 cm in size).

Generalised Structure
An extensive compartmentalisation of cytoplasm is seen through the presence of membrane bound organelles. Eukaryotic cells also possess a variety of locomotory and cytoskeletal structures.

All eukaryotic cell are not-identical, instead they differ from each other on the basis of structure and function. Cell wall is a special membrane, being present in plants, fungi and some protists. Plants cells also contains a large vacuole and plastids, which are absent in animal cells, while animal cells possess centrioles, which are absent in plant cells.
Differences between Plant and Animal Cell

Characters	Animal Cells	Plant Cells
Cell wall	Absent	Present (formed of cellulose)
Shape	Round (irregular shape)	Rectangular (fixed shape)
Centrioles	Present in all animal cells.	Only present in lower plant forms.
Vacuole	One or more small vacuoles (much smaller than plant cells).	One, large central vacuole taking up 90% of cell volume.
Cytoplasm	Present	Present
Ribosomes	Present	Present
Plastids	Absent	Present
Plasma membrane	Only cell membrane	Cell wall and a cell membrane.
Golgi apparatus	Present	Present
Mitochondria	Present	Present
Endoplasmic reticulum (smooth and rough)	Present	Present
Chloroplast	Animal cells don't have chloroplasts because they don't have the ability to prepare their food.	Plant cells have chloroplasts because they make their own food (autotrophs).
Flagella	May be found in some cells	May be found in some cells.
Microtubules	Present	Present
Microfilaments	Present	present
Cilia	Present	It is very rare
Lysosomes	Lysosomes occur in cytoplasm.	Lysosomes usually not evident.
Nucleus	Present	Present
Cytokinesis	Result in the formation of a furrow in the centre of a cell.	Occurs due to the formation of a cell plate.





Components of a Eukaryotic Cell

An eukaryotic cell is composed of various cell components as cell membrane, cell wall (only in plants), mitochondria, chloroplast, Golgi bodies, ribosomes, centrioles (only in animals), etc.

All these are described here under in detail.

Cell Membrane

Every living cell is covered by a thin, elastic, transparent, semi-permeable and regenerative membrane called cell membrane also called plasma membrane or plasmalemma. The plasma membrane separates the internal environment of the cell from external environment. As this membrane helps in regulating the entrance and exit of molecules into and out of the cell.

In 1950s with the advancement of electron microscope the detailed structure of the membrane was studied. Most of the initial studies on cell membrane structure, i.e., especially on the human Red Blood cells (RBCs), which enabled the scientists to deduce the possible structure of plasma membrane.

Human RBCs are considered to be the best material for the : study of biochemical composition of the cell membrane because they lack nucleus as well as cytoplasmic organelles.

Structure

Studies on human RBCs concluded that the cell membrane is composed of lipid which forms a bilayer with protein molecules embedded in it at places. Later it was revealed that cell membranes also possess protein and carbohydrates.

Lipid

The lipid molecules are amphipathic in nature and are arranged within the membrane by the help of two types of ends. These are as follows
(i) Polar Hydrophilic End This region is in the form of (water loving) head, which faces towards the outer sides of the cell membrane to interact with the aqueous environments on both sides.

(ii) Non-polar Hydrophobic End This region is in the form of (water repelling) tail, both ends of which faces each other that occur towards the centre of the cell membrane.
The proportion of lipid molecules varies in plasma membrane of different cell types. These are formed of cholesterol (25-32%) and mainly of phosphoglycerides or phospholipids (55-75%).
Outside of cell Phosphatidylcholine

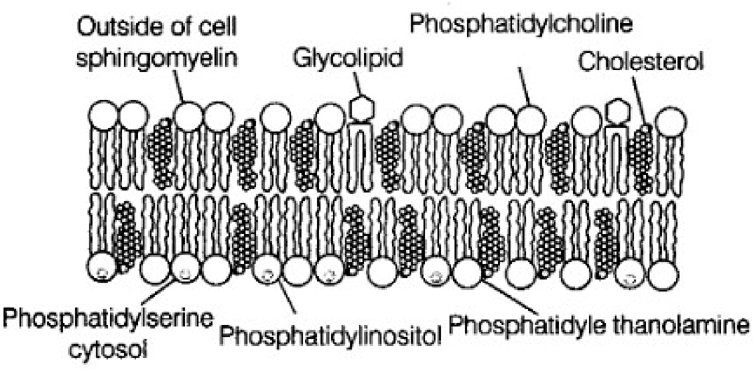


Fig. 8.5 Generalised view of plasma membrane

Proteins

Depending upon the ease of extraction, the ratio of protein and lipid varies considerably in different cell types. In human beings, the membrane of the erythrocytes (RBCs) has approximately 52% protein and 40% lipid.

The membrane proteins can be classified as
(i) Integral Proteins (intrinsic protein) They have stronger association and bound firmly to the membrane. These proteins are buried partially or totally in the phospholipid bilayer.
(ii) Peripheral Proteins (extrinsic protein) They have weaker association and are bound to lipids of membrane by electrostatic interactions.

Carbohydrates
These constitute about 1-5% of chemical composition of plasma membrane. These are associated with the phospholipids or with the peripheral proteins to form glycolipids and glycoproteins respectively.
To understand the structure of plasma membrane various models are given out of which the most accepted model is Fluid Mosaic Model.

Fluid Mosaic Model
This model was given by Singer and Nicholson (1972). According to this model, the lipid bilayer and integral proteins appear like a mosaic arrangement and the quasi-fluid nature of lipid enables the lateral movement of the proteins within the overall bilayer.
This ability of proteins to move within the membrane indicate the fluidity of the lipid part.

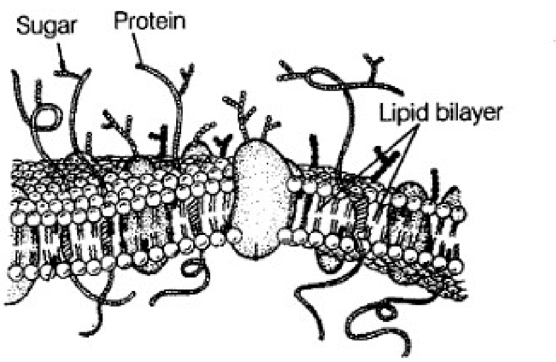


Fig.8.6 Fluid mosaic model of plasma membrane

Fluidity of Membrane
The fluid nature of the membrane is important from the point of view of interactions of molecules within the membrane as well as other functions like formation of inter cellular junctions, cell growth, secretion, endocytosis, cell division, etc.
Passage of substances across the membrane occurs mainly by two methods

i- Active Transport

Active transport is the movement of the molecules across the membrane against their concentration gradient, i.e., from lower to the Tighter concentration. It is an energy dependent process, in which ATP is utilised. It occurs in few ions and molecules,
e.g., Na^+ / K^+ pump.
Polar molecules requires a carrier protein of the membrane to facilitate their transport across the membrane because they cannot pass through the non-polar lipid bi-layer.

ii- Passive Transport

Passive transport is the mode of movement of molecules or substances across the membrane without any requirement of energy.

It can be further of following three types

(a) Osmosis It is the process by which water molecules pass through a membrane from a region of higher concentration to a lower concentration.
(b) Simple Diffusion In this process, neutral molecules move across the membrane along the concentration gradient (from higher to lower concentration), e.g., Gases and small molecules.
(c) Facilitated Diffusion In this process, the molecules are transported along concentration gradient by the help of ion channels and permeases. Energy is not required in this process.

Differences between Active and Passive Transport

Active Transport	Passive Transport
In this process, energy is required.	Energy is not required.
It is a rapid process.	It is comparatively slower process.
It occurs usually against the concentration gradient.	It occurs along the concentration gradient.
It is highly selective.	It is non-selective.
It requires carrier proteins.	It occurs without carrier proteins.

Functions

Cell membrane possess the following functions

(i) It is a selectively permeable or semi-permeable membrane, allows only selected substances to pass inwardly.
(ii) It protects the cell from injury.
(iii) Membranes have carrier proteins for active transport.

(iv) Cell membrane contain enzymes which perform certain reaction on their surface, e.g., ATPase, phosphatase, etc.

Cell Wall

It was first discovered by Robert Hooke (1665). It is a rigid and a non-living structure which forms an outer covering of the plasma membrane in plants and fungi. It is absent in animal cells.

Cell wall is metabolically active in nature and is capable of growth. Its thickness varies from 0.1-10 pm.

Cell wall not only gives shape to cell and protects the cell from mechanical damage and infection, it also helps in cell to cell infraction and provides barrier to undesirable macromolecules.

Chemical Composition

The cell wall of algae is made up of cellulose, galactans, mannans and minerals like calcium carbonate, etc., while cell wall of plant is composed of cellulose, hemicellulose, pectins and proteins.

i.Structure of Cell Wall

On the basis of the structure, cell wall is differentiated into the following three parts

Middle Lamella

It is the layer mainly made up of calcium and magnesium pectates. It cements the cell walls of two adjoining cells together. It is absent on the outer side of surface cells middle lamella along with a cell wall transversed by plasmodesmata which connects cytoplasm of ^ neighbouring cells.

ii. Primary Cell Wall

It is produced inner to the middle lamella in a young and growing cell. It is capable of growth and extension. It tends to diminish gradually as the cell attain maturity.

iii. Secondary Cell Wall

The thick secondary wall is formed inner towards membrane to the primary wall. As the cell gets fully matured. Its composition is similar to the primary wall.

Functions

Cell wall possess the following functions

(i) It helps in providing a definite shape to the cell and also protects protoplasm against any mechanical injury, i.e., damage and infection.
(ii) It also helps in cell-to-cell interaction.
(iii) It provides barrier to undesirable macromolecules and attack of pathogens.

Endomembrane System

The endomembrane system consists of nuclear envelope, Endoplasmic Reticulum (ER), Golgi complex, lysosomes and vacuoles suspended in the cytoplasm.

These are considered together as an endomembrane system because their functions are coordinated with each other, inspite of this that each membranous organelles is distinct in terms of its structure and functioning.

Endoplasmic Reticulum (ER)

The endoplasmic reticulum is a complicated system of membranous channels and flattened vesicles. It is physically continuous with the outer membrane of the nuclear envelope. It is revealed from the electron microscopic studies of eukaryotic cells that there is a presence of a network or reticulum of tiny tubular structures that are being scattered in the cytoplasm.

ER is known to be absent in prokaryotes but is present in all eukaryotic cells except germinal cells and mature human RBCs.

Endoplasmic reticulum divides the intracellular space into two main compartments
(i) Luminal (inside ER) compartment
(ii) Extra-luminal (cytoplasm) compartment,

Types of Endoplasmic Reticulum

Endoplasmic reticulum are mainly of two types, depending upon the nature of its membranes
(i) Smooth Endoplasmic Reticulum (SER) These are smooth because they do not bear ribosomes in the form of granules on their surfaces. It is present in cells where they acts as a major site for the synthesis of lipid and also helps in synthesis of steroidal hormone in animal cells.
(ii) Rough Endoplasmic Reticulum (RER) They are found extensive and continuous

with the outer membrane of nucleus. These have rough membrane because they bear ribosomes being attached to their surfaces.
They are actively being seen in the cells which have their involvement in the synthesis and secretion of proteins.

Functions
Endoplasmic reticulum possess the following functions
(i) It provides support to the colloidal cytoplasmic matrix.
(ii) Helps in the rapid intracellular transport of the material.
(iii) ER membranes contains a variety of enzymes for various metabolic processes, e.g., ATPase,
phosphatases, etc.

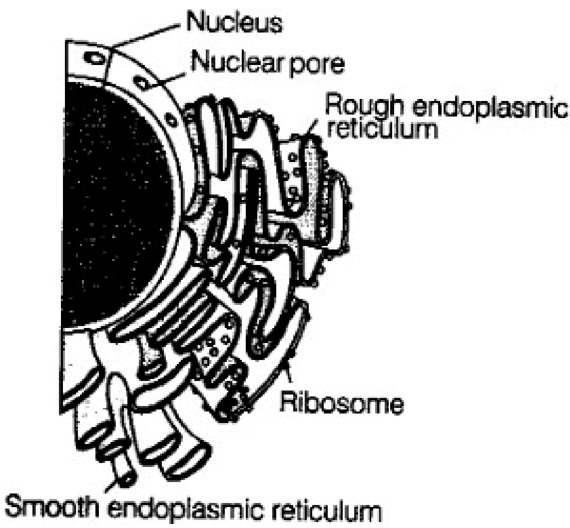


Fig.8.7 Structure of an endoplasmic reticulum

Differences between SER and RER

SER	RER
It is not associated with ribosomes but generally associated with plasma membrane.	It is associated with ribosomes and nuclear membrane.
Its main function is synthesis of proteins.	Its main function is synthesis of lipids.
Formed of vesicles and tubules.	Formed of cisternae and few tubules.
It is usually found in periphery.	It is found deep inside the cytoplasm.

2. Golgi Apparatus
It was first discovered by Camillo Golgi (1898), when he was observing the densely

stained reticular structures being present near the nucleus of the cell. These structures were named Golgi bodies after his discovery.
Golgi complex or Golgi apparatus is a major complex protoplasmic structure being made up of many flat, disc-shaped sacs or cisternae (0.5-1.0 nm) in diameter.

Occurrence
Golgi complex, occurs in all cells except prokaryotes (i.e., PPLO, bacteria, cyanobacteria) and some eukaryotes such as human RBCs, sieve tubes of plants, etc.

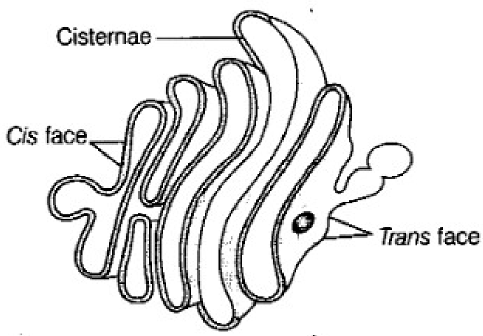


Fig.8.8 Golgi apparatus

Cisternae of Golgi apparatus are found stacked parallel to each other. They vary in number in a Cell. They are often curved-like a shallow bowls to give Golgi complex a definite polarity.
They are concentrically arranged near the nucleus with two distinct faces
(i) Cis face {forming face) This is convex in shape that lies towards the cell membrane and is responsible for receiving secretory materials through the transitional vesicles, which are pinched off from the SER.
(ii) Trans face (maturing face) This is concave in shape that lies towards the nucleus and is responsible for releasing the material, which is being secreted by cis face and modified in the cisternae.

Note:

- Although, the cis and the trans faces of the organelle are entirely different in origin, but they inter connect each other.
- Proteins that are synthesised by ribosomes on ER are first modified in cisternae before they released from its trans face.
- The Golgi apparatus acts as a site where the material to be released is being packaged in the form of vesicles delivered either to the intracellular targets or secreted outside the cell.

Functions

Golgi apparatus possess the following functions

(i) The Golgi apparatus is involved in the formation of lysosomes, vesicles that contain proteins and remains within the cell.
(ii) It performs the function of packaging material.
(iii) It acts as an important site for the formation of glycoproteins and glycolipids.
(iv) It helps in the production of complex carbohydrates other than glycogen and starch.
(d) It helps in the formation of cell wall.

3. Lysosomes

These are membrane bounded vesicles that are produced by the Golgi apparatus. They are rich in several hydrolytic digestive enzymes (hydrolases-lipases, proteases, carbohy- drases, etc). As these are optimally active at the acidic pH (less than 7). Therefore, are also called acid hydrolases and are capable of digesting macromolecules from various sources like carbohydrates, lipids and nucleic acids.

Functions

Lysosomes possess the following junctions

(i) They digest the food contents (intra cellular digestion).
(ii) They also perform extracellular digestion.
(iii) They also digest the old and useless organelles of the cells.
(iv) They also have functioning in cell division.
These are called suicidal bags due to the presence of hydrolytic enzymes.
De Duve observed the rounded bodies in liver cells and called them pericanalicular dense bodies (1949).

4. Vacuoles

Vacuole are a large membranous sac found in the cytoplasm. These store substances that are not essentially useful for the cell (like water, sap, excretory product and other materials). Plant vacuoles contain not only water, sugars and salts but also contain pigments and toxic molecules and also occupy up to 90% of the volume of the cell.
The vacuole is bounded by a single membrane structure known as tonoplast which in plant cells, facilitates the transport of materials and some ions against the concentration gradient inside the vacuole. Thus, the concentration of material is tend to be the higher in vacuole, than to be in the cytoplasm

Animal cells also have vacuole, but they are much more prominent in case of plant cells. Thus, plant cells have typically large central vacuole filled with a watery fluid that gives added support to the cell.

Following types of vacuoles are being found in different organisms
(i) Contractile Vacuole They play an important part in osmoregulation and excretion in Amoeba, etc. It occurs mosdy in protistan and algal cells that are found mainly in water.
(ii) Food Vacuole They occur in the cells of mainly protozoan protists. These are formed by engulfing the food particles, i.e., by the fusion of lysosome and phagosome. The digested material thus, passes out into the surrounding cytoplasm. Air vacuoles and sap vacuoles are the another types of vacuoles being formed by the cells.

Mitochondria
Mitochondria are membrane bound cell organelles, essential for aerobic respiration of eukaryotic cells. These are also known as power house of the cell. Thus, they produces cellular energy in the form of ATP.

Occurrence
Mitochondria are present in all living cell except, prokaryotic cell and certain specialised eukaryotic cell such as anaerobic cells and mature RBCs.

It is revealed from the studies that mitochondria is not easily visible, unless it is specifically stained.

Shape and Size
Mitochondria vary considerably according to the shape and size. They have varying shape such as granular fibrillar, spherical, oval, discodial, etc. Average size of mitochondria is 2-6 |im in length and 0.5 pm in diameter (typical cylindrical or sausage-shaped mitochondria has diameter of 0.2-1.0 Jim).

Ultrastructure
A mitochondrion contains two membranes, i.e., outer and inner. Out of which outer membrane is smooth and forms the continuous boundary of the organelle. The inner membrane is semipermeable to some metabolities. It is infolded into the matrix as incomplete partitions called cristae.

The cristae are responsible for increasing the physiological active area or surface area. The density of cristae determines the intensity of respiration.

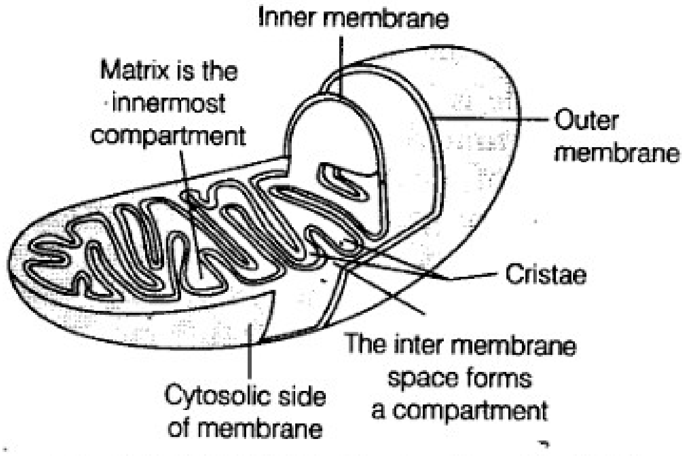


Fig. 8.9 Structure of mitochondria (LS)

The outer and the inner membranes divides its lumen into two aqueous compartments separately, i.e., the outer and the inner compartment.

Inner compartment is also called matrix, which forms the inner core of the mitochondrion. The matrix also possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. The mitochondria divide by fission.

The two membranes of mitochondria have their own specific enzymes associated with mitochondrial function.

Functions

Mitochondria possess the following functions

(i) Mitochondria provide important intermediates for the synthesis of several biochemicals like pyrimidines, alkaloids, etc.
(ii) The inner chamber matrix of the mitochondria has enzyme for the synthesises of fatty acids.
(iii) Helps in regulation of cellular metabolism.
(iv) Helps in apoptosis (programmed cell death).
(v) Each of membrane potential.
Mitochondrion is the second largest cell organelle and are more in animal cells than in plant cells.

Plastids

These are semi-autonomous organelles that have double membrane envelope. Plastids have their own genetic material (i.e., DNA). Due to their large size, they are easily seen under the microscope.

Occurrence
Plastids are found in all plant cells and euglenoides except in some protistans (e.g., Euglena, Dinophyceae, etc).

Types
Plastids are differentiated into three different types on the basis of the colour, i.e., type of pigments found in them.

Leucoplasts
These are the colourless plastids of varied shapes and sizes with stored nutrients in the form of carbohydrates lipids and proteins.

These are of following three types
(a) Amyloplasts are the carbohydrates (starch) containing leucoplast, e.g., Rice, wheat, potato, etc.
Amyloplasts are larger than the normal/original size of leucoplast.
(b) Elaioplasts are the leucoplast which stores oils and fats, e.g, Tuberose endosperm of castor seeds, etc.
(c) Aleuroplasts are the protein storing leucoplast.
e.g., Maize (aleurone cells).

ii. Chromoplasts
These are the leucoplast, whioh are yellow or reddish in appearance because of the presence of fat soluble carotenoid pigment carotene.
Xanthophyll and some other pigments are also present as the fat soluble carotenoid pigment other than carotene, e.g., Orange colour of carrot, etc.

iii. Chloroplasts
These are the plastids which are greenish in colour containing photosynthetic pigments chlorophyll and carotenoids. These pigments are responsible for trapping the light energy, essential for the photosynthesis, i.e., the synthesis of organic food from an inorganic raw materials in the presence of sunlight.

Occurrence
Chloroplasts occur in major number in the photosynthetic mesophyll cells of leaves and green stem.

Shape and Size
• They may be lens-shaped, oval, spherical, discoid or even ribbon-like organelles. They also have variable length (5-10 mm) and width (2-4 mm).
Number
Their number also varies from one per cell of the Chlamydomonas (a green alga) to 2-40 per cell in mesophyll.

infrastructure
Chloroplasts are also bounded by double membrane envelope like mitochondria, the two membranes are smooth and are thick of about 90-100 A. The inner membrane of chloroplast is less permeable than the other one.
The inner membrane is grounded by a space known as stroma or matrix, a dense, colourless and a granular substance mainly formed of soluble proteins. It also contains enzymes which are essential for the synthesis of carbohydrates, lipids and proteins.

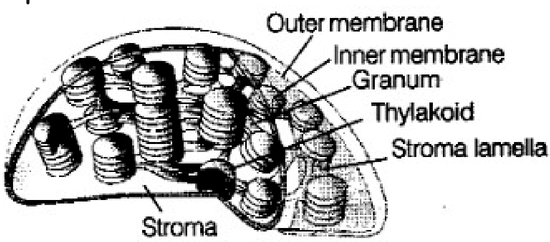


Fig 8.10 Sectional view of chloroplast

Thylakoids are number of membranous like flattened structures that run throughout the matrix or stroma. When several thylakoids are arranged or organised in the stack (like the piles of coins), called grana or the intergranal thylakoids. Many flat membranous tubules interconnect the thylakoids of different grana known as stroma lamellae.

Functions
Chloroplasts possess the following functions
(i) Helps in photosynthesis, i.e., formation of organic compounds.
(ii) In consumption of C02 and release of 02 in photosynthesis.
(iii) May also change into chromoplast in order to provide colour to many flowers

and fruits.
(iv) Helps in storing fat and lipids.

(v) Functions in transduction of energy.
Note:
* The sum total of all plastids in a cell is called plastidome.
* The chloroplast with nitrogen fixing genes are called nitroplast.
* The space between the two membrane is called intermembrane space, which separates the two membrane. This space contains a narrow fluid. Stroma also contains small, double-stranded circular DNA, molecules and ribosomes.

Ribosomes of chloroplasts are smaller (70S) than the ribosomes of cytoplasm (80S).Ribosomes
These are the small sub-spherical granular organelles, not bounded by any membrane. Ribosomes were first observed by George Palade (1953), as the dense particles under the electron microscope. Hence, are also called Palade particles.

Ribosomes are mainly composed of ribonucleoproteins (i. e., RNA-t- proteins) and are also known as protein factories, as they are primarily involved in the synthesis of proteins or polypeptides.

As studied earlier, the prokaryotic ribosomes are 70S type, while the eukaryotic ribosomes are 80S type. Here, 'S' (Svedberg's unit) stands for sedimentation coefficient (measure of density and size).
Both 70S and 80S ribosomes contains two sub-units, i.e., the smaller and the larger sub-unit .
Differences between 70S and 80S Ribosomes

70S Ribosomes	80S Ribosomes
They are found in prokaryotes (bacteria, cyanobacteria and viruses).	They are found in eukaryotes (algae, fungi, higher plants and animals).
Larger sub-unit (50S)	Larger sub-unit (60S)
Small sub-unit (30S)	Smaller sub-unit-(40S)
Comparatively smaller	Larger than 70S
Synthesised in cytoplasm	Synthesised inside the nucleolus
RNA: protein = 60:40	RNA: protein = 50:50

Cytoskeleton

The network of interconnected proteinaceous filaments and tubules, which extends from the nucleus to the plasma membrane in eukaryotic cells.

Functions

Cytoskeleton possess the following functions

(i) The cytoskeletal structures maintain the shape of the cell and its extensions.
(ii) It is also involved in many functions in a cell as mechanical support, motility, etc.

Cilia and Flagella

These are hair-like projections of cell membrane. Both cilia and flagella are almost identical in structure but differ somewhat in length. As cilia are small structures, working as oars (causing the movement of either the cell or the surrounding fluid), while flagella are comparatively longer in size than cilia and are responsible for the movement of cell.

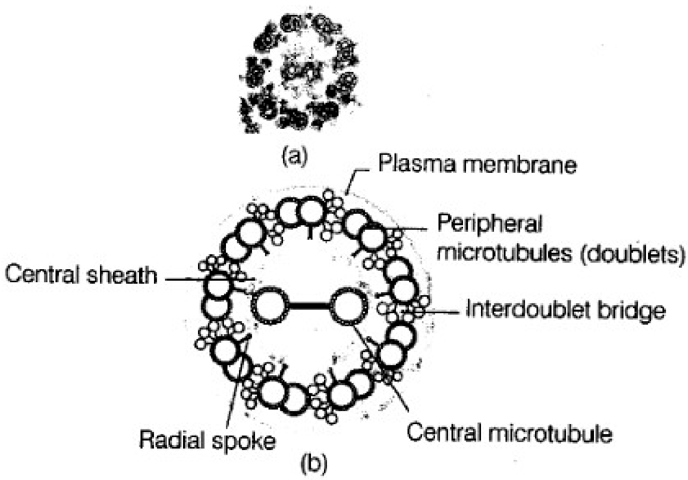


Fig 8.11 Section of cilia /flagella showing different parts (a) Electron micrograph (b) Diagram representation of internal structure

According to the electron microscopic studies it is predicted that the cilium or the flagellum are covered with plasma membrane. Their core called the axoneme, contains a number of microtubules, running parallel to the long axis.
Usually, the axoneme has nine pairs of doublets of peripheral microtubules that are radially arranged and a pair of centrally located microtubules. This arrangement of axonemal microtubules is referred to as the (9 + 2) array.
The central tubules are connected by bridges and is also enclosed by a central sheath, which is connected to one of the tubules of each peripheral doublets by a radial spoke.

Thus, it has been estimated that there are nine radial spokes. The peripheral doublets are also interconnected by linkers. Both the cilium and flagellum emerge from centriole like structure called the basal bodies.

Differences between Cilia and flagella

Cilia	Flagella
Cilia are short, hair-like organelles, 2-20 μm in length.	Flagella are long, whip-like organelles that may be 10-200 μm long.
They occur relatively in large numbers per cell.	They are usually fewer per cell.
They often cover the entire cell or the entire exposed surface of a cell.	They are often at one end of a cell.
They show sweeping or rowing motion.	They show undulatory motion.

Flagella are also present in prokaryotic bacteria but these are ' structurally different from that of eukaryotic flagella.

Centrosomes and Centrioles

Centrosome is an organelle that generally have two cylindrical structures known as centrioles. They are basically surrounded by an amorphous pericentriolar materials. Both the centrioles in a centrosome lie perpendicular to each other in which each has an organisation like the cartwheel.

They are usually made up of nine evenly spaced peripheral fibrils (triplet in nature) of tubulin protein. With which adjacent triplets are also being linked.

The centre part of the proximal region of the centriole possess rod-shaped proteinaceous mass known as hub, which is connected with tubules of the peripheral triplets fibrils known as radial spokes (made up of protein).
From the basal body of cilia or flagella the centrioles and spindle fibres give rise to spindle apparatus during cell division in animal cells.

Functions

Centrosomes and centrioles possess the following functions

(i) These forms spindle fibres and move to the poles, at the time of cell divisidn,

which thus, help in the movement of chromatids in daughter cells.
(ii) Help in the formation of cilia and flagella of the cells.

Nucleus
It is a specialised and principle cell organelle of the cell, which contains all the genetic information for controlling all essential processes related to metabolism and transmission.
Nucleus was first described by Robert Brown as early as 1831.
Later the name chromatin was given by Flemming when the material of the nucleus was stained by the basic dyes.
Nucleus is known to be the largest cell organelle also known as brain of the cell.

Occurrence
A nucleus is known to be present in all eukaryotic cells except a few cell types such as RBCs of humans, sieve cells of vascular plants, etc.
Prokaryotic cell lack a well organised nucleus, instead they have a nucleoid.

Ultrastructure
The interphase nucleus (nucleus of a cell when it is not dividing) has highly extended and elaborate nucleoprotein fibres called chromatin, nuclear matrix and one or more spherical bodies called nucleoli.

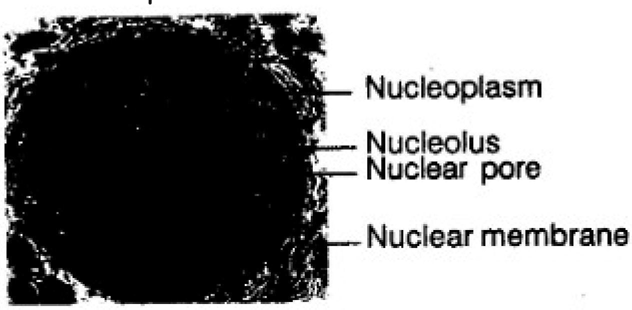


Fig 8.12 Ultrastructure of interphase nucleus

Microscopic Structure
It has been revealed from the studies of electron microscopy that the nuclear envelope, consists of two parallel membranes with a space between 10-50 nm called the perinuclear space, which forms a barrier between the materials present inside the nucleus and that of the cytoplasm.

The outer membrane usually bears ribosomes on it andremains continuous with the endoplasmic reticulum. The nuclear envelope is interrupted by minute nuclear pores, at a number nuclear of places, which are produced by the fusion of its two membranes. These nuclear pores are the passages through which movement of RNA and protein molecules takes place in I both directions between the nucleus and the cytoplasm.

Normally, there is only one nucleus per cell, but variations in the number of nuclei can also be seen in various organisms.

Nucleus is differentiated into following four parts

i. Nuclear Envelope

It is a double membrane bound envelope that surround the nucleus and separates the latter from the cytoplasm.

ii. Nucleoplasm

It is a clear, non-staining, fluid material present in the nucleus, which contains raw materials (nucleotides), enzymes (DNA/RNA polymerases) and metal ions for the synthesis of RNAs and DNA. The nuclear matrix or the nucleoplasm is composed of nucleolus and chromatin (spherical structures present in the nucleoplasm).

iii. Nucleolus

It is a naked, round and slightly irregular structure, which is attached to the chromatin at a specific region. The content of nucleolus is continuous with the rest of the nucleoplasm as it is not a membrane bound structure.

It is a site for active ribosomal RNA synthesis. Larger and more numerous nucleoli are present in cells actively carrying out protein synthesis.

Chromatin

It is named so, because it has the ability to get stained with certain basic dyes. It is known to be the hereditary DNA protein fibrillar complex. The chromatin fibres are distributed throughout the nucleoplasm.

It has two distinct regions

(a) Euchromatin (lightly stained)

(b) Heterochromatin (darkly stained)

Functions

Nucleus possess the following functions

(i) It stores information that control cellular functions.

(ii) It controls the synthesis of structural proteins.

(iii) It also stores the genetic information for development reproduction and behaviour.
(iv) It also induces genetic variations.

Chromosomes
It has been already studied in the chapter that the nucleus in the interphase has a loose and indistinct network of nucleoprotein fibres called chromatin. But during different stages of*cell division cells show structured chromosomes in place of the nucleus. The chromosomes are meant for the equal distribution of genetic material. Their number is fixed and is same in all individuals of a species.

Chromatin is composed DNA and some basic proteins called histones. Some non-histone proteins and RNA are also present in the chromatin.

A single human cell has approximately two metre long thread of DNA distributed among its 46 (23 pairs) chromosomes.

Each and every chromosome is composed of a primary constriction or the centromere. On the sides of which the disc-shaped structures are present known as kinetochores.

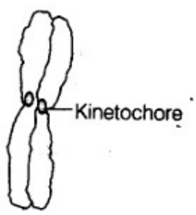


Fig 8.13 Chromosome with kinetochore

On the basis of the position of the centromere, the chromosomes can be classified into four following types
i. Metacentric Chromosome
It has chromosome with equal arms and centromere lies in the centre.

ii. Sub-metacentric Chromosome
It has one shorter arm and one longer arm with centromere slighdy away from the middle of the chromosome.

iii. Acrocentric
It forms one extremely short and one very long arm and centromere is located near the end of the chromosome.

iv. Telocentric
It has the terminal centromere, i.e., centromere is placed at an extreme end. Telocentric chromosomes are not present in humans.

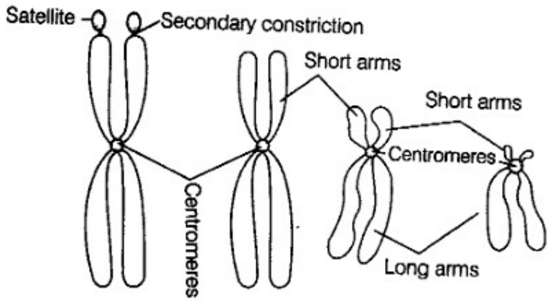


Fig. 8.14 Types of chromosomes based on the position of centromere

Few chromosomes have a non-staining secondary constrictions being present at a constant location at some or the other time which gives the appearance of a small fragment known a satellite.

Functions

Chromosomes possess the following functions

(i) Control cellular differentiation.
(ii) Contains all hereditary information located in the genes.
(iii) Forms a link between the offspring and the parents.
(iv) Introduce variations, through the process of crossing over.
(v) Control cell metabolism.

Microbodies

These are the membrane bound cytoplasmic elements that are composed of enzymes and other substances. These are minute vesicles found in both plant cells and animal cells, e.g., In the liver, kidney, Protozoa, yeast and many other types of cells. Their shape can be ovoid, spherical, granular, etc.

Peroxisomes and glyoxysomes are the types of microbodies being found in plant cell and animal cell respectively.

MCQ Questions for Class 5 Biology Cell: The Unit of Life with Answers

Question 1.
The cytoplasmic connections from cell to cell are known as
(a) middle lamella
(b) plasmodesmata
(c) cell membrane system
(d) endoplasmic reticulum

Answer
Answer: (b) plasmodesmata

Question 2.
Bacterial flagella is made up of
(a) tubulin
(b) flagellin
(c) chitin
(d) None of these

Answer
Answer: (b) flagellin
Explanation:
Bacterial flagella is made up of protein flagellin.

Question 3.
Plasmolysis occurs due to-
(a) Absorption
(b) Endosmosis
(c) Osmosis
(d) Exosmosis

Answer
Answer: (d) Exosmosis

Question 4.
The term Cell was given by-
(a) Leeuwenhoek
(b) Robert hooke
(c) Flemming
(d) Robert Brown

Answer
Answer: (b) Robert hooke

Question 5.
Which one of the following also acts as a catalyst in a bacterial cell?
(a) 23 sr RNA
(b) 5 sr RNA
(c) sn RNA
(d) hn RNA

Answer
Answer: (a) 23 sr RNA

Question 6.
Centrosome is found in-
(a) Cytoplasm
(b) Nucleus
(c) Chromosomes
(d) Nucleolus

Answer
Answer: (a) Cytoplasm

Question 7.
Plasma membrane is
(a) impermeable
(b) semi-permeable
(c) completely permeable
(d) differentially permeable

Answer
Answer: (b) semi-permeable
Explanation:
Plasma membrane is a selective permeable membrane that allows only selective molecules to pass through it.
The permeability depends on the electric charge and polarity of the molecules.

Question 8.
Middle lamella is made up of ___________.
(a) calcium sulphide
(b) calcium pectate
(c) calcium carbonate
(d) calcium chloride

Answer
Answer: (b) calcium pectate
Explanation:
Middle lamella is made up of calcium pectate.

Question 9.
Match the columns.
1. Cytoskeleton – A. hair-like outgrowth
2. Flagella – B. proximal region of centriole
3. Hub – C. bristle-like structures
4. Fimbriae – D. filamentous protein structure
(a) 1-D, 2-A, 3-B, 4-C
(b) 1-D, 2-C, 3-B, 4-A
(c) 1-B, 2-D, 3-A, 4-C
(d) 1-D, 2-A, 3-C, 4-B

Answer
Answer: (a) 1-D, 2-A, 3-B, 4-C
Explanation:
A filamentous protein structure present in the cytoplasm is called cytoskeleton.
Flagella is a hair-like outgrowths of the cell membrane.
The central part of the proximal region of the centriole is called hub.
Fimbriae are small bristle like fibres sprouting out of the cell.

Question 10.
Which of the following does not have cell wall?
(a) Mycoplasma
(b) Bacteria
(c) PPLO
(d) Blue green algae

Answer
Answer: (a) Mycoplasma
Explanation:
Mycoplasma does not have cell wall.
PPLO (Pleuro Pneumonia Like Organisms)

Question 11.
Centrosome is found in-
(a) Cytoplasm
(b) Nucleus
(c) Chromosomes
(d) Nucleolus

Answer
Answer: (a) Cytoplasm

Question 12.
The longest cell in human body is
(a) red blood cells
(b) white blood cells
(c) columnar epithelial cells
(d) nerve cells

Answer
Answer: (d) nerve cells
Explanation:
Nerve cells are the longest cells.

Question 13.
The main site for synthesis of lipids is

(a) vacuoles
(b) RER
(c) SER
(d) Golgi body

Answer
Answer: (c) SER
Explanation:
The main site for synthesis of lipid is smooth endoplasmic reticulum.

Question 14.
The function of ribosomes is
(a) metabolism
(b) lipid synthesis
(c) protein synthesis
(d) photosynthesis

Answer
Answer: (c) protein synthesis
Explanation:
Ribosomes are called protein factories because they synthesize proteins.

Question 15.
Which is called Suicidal Bag?
(a) Centrosome
(b) Lysosome
(c) Mesosome
(d) Chromosome

Answer
Answer: (b) Lysosome

Question 16.
A nucleosome is a portion of the chromonema containing _______.
(a) both DNA and histones
(b) only histones

(c) both DNA and RNA
(d) only DNA

Answer
Answer: (a) both DNA and histones

Question 17.
The largest cell in the human body is-
(a) Nerve cell
(b) Muscle cell
(c) Liver cell
(d) Kidney cell

Answer
Answer: (a) Nerve cell

Question 18.
Keeping in view the fluid mosaic model for the structure of cell membrane, which one of the following statements is correct with respect to the movement of lipids and proteins from one lipid monolayer to the other (described as flip-flop movement)?
(a) Neither lipids, nor proteins can flip-flop
(b) Both lipids and proteins can flip-flop
(c) While lipids can rarely flip-flop, proteins can not
(d) While proteins can flip-flop, lipids can not

Answer
Answer: (c) While lipids can rarely flip-flop, proteins can not

Question 19.
Cell secretion is done by-
(a) Plastids
(b) ER
(c) Golgi apparatus
(d) Nucleolus

Answer

Answer: (c) Golgi apparatus

Question 20.
____________ increases the surface area for mitochondrial activity.
(a) Inner membrane
(b) Inter membrane space
(c) Matrix
(d) Cristae

Answer
Answer: (d) Cristae
Explanation:
The inner membrane forms a number of foldings called cristae towards the matrix. These cristae increases the surface area.

Solutions for Class 11 Biology Chapter 8 Cell The Unit of Life:

Section Name	**Topic Name**
8	Cell The Unit of Life
8.1	What is a Cell?
8.2	Cell Theory
8.3	An Overview of Cell
8.4	Prokaryotic Cells
8.5	Eukaryotic Cells
8.6	Summary

TEXTBOOK QUESTIONS SOLVED

1.Which of the following is not correct?
(a) Robert Brown discovered the cell.
(b) Schleiden and Schwann formulated the cell theory.
(c) Virchow explained that cells are formed from pre-existing cells.
(d) A unicellular organism carries out its life activities within a single cell.
Soln.(a) Robert Hooke discovered the celland Robert Brown discovered nucleus in the cell.

2.New cells generate from
(a) bacterial fermentation
(b) regeneration of old cells
(c) pre-existing cells
(d) abiotic materials.
Soln.(c)

•

3.Match the following.

Column I	Column II
(a) Cristae	(i) Flat membranous sacs in stroma
(b) Cisternae	(ii) Infoldings in mitochondria
(c) Thylakoids	(iii) Disc-shaped sacs in Golgi apparatus

Soln.a – (ii); b – (iii); c – (i).

4.Which of the following is correct?
(a) Cells of all living organisms have a nucleus.
(b) Both animal and plant cells have a well defined cell wall.
(c) In prokaryotes, there are no membrane bound organelles.
(d) Cells are formed de novo from abiotic
Soln. (c) Mature mammalian erythrocytes and sieve tube cells of vascular plants lack nucleus. Animals lack cell wall and only cell membrane is present. Prokaryotes are unicellular organisms which lack nucleus and other membrane bound organelles. All cells arise from pre-existing cells.

5.What is a mesosome in a prokaryotic cell? Mention the functions that it performs.
Soln. Mesosome is a membranous structure in prokaryotic cell, which is formed by the extensions of the plasma membrane into the cell in form of vesicles, tubules and lamellae. Mesosomes are equal to mitochondria in eukaryotes, as they perform aerobic cellular respiration in prokaryotes. It helps in DNA replication and distribution of genetic material to daughter cells. Mesosomes also help in respiration, increase the surface area of the plasma membrane and enzymatic content and cell wall formation.

6.How do neutral solutes move across the plasma membrane? Can the polar molecules also move across it in the same way? If not, then how are these

transported across the membrane?

Soln. Neutral solutes move across the membrane by the process of simple diffusion along the concentration gradient i.e., from higher concentration to the lower concentration. Polar molecules cannot pass through the nonpolar lipid bilayer, they require carrier proteip of the membrane to facilitate their transport across the membrane. In facilitated diffusion, molecules are transported along concentration gradient by help of ion channels and permeases and it does not involve energy expenditure (passive transport).

7. Name two cell-organelles that are double membrane bound. What are the characteristics of these two organelles? State their functions and draw labelled diagrams of both?

Solution: Mitochondria and chloroplast are double membrane bound organelles. Mitochondria: Mitochondria are cylindrical or sausage shaped cell organelles and contains two membranes, outer and inner. The inner compartment is called the matrix containing DNA, RNA, ribosomes, enzymes of Krebs cycle etc and outer membrane forms the continuous limiting boundary of the organelle. Inner membrane forms number of infoldings called the cristae which increases the surface area. Oxysomes are present on inner mitochondrial membrane. Mitochondria are semiautonomous organelles, i.e., have their own DNA and ribosomes.

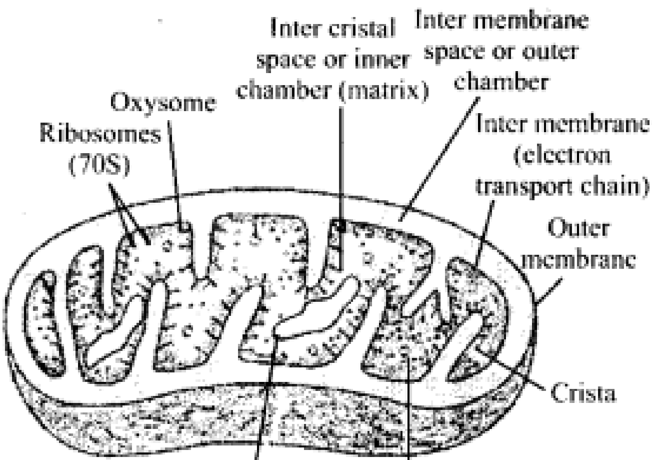


Fig.: A mitochondrion in section.

Functions of mitochondria:

- Mitochondria are essential for aerobic respiration.

- Mitochondria provide intermediates for synthesis of important biomolecules such as chlorophyll, cytochrome, steroids etc.
- Mitochondria regulate the calcium ion concentration in the cell.
- Mitochondrial matrix contains enzymes for the synthesis of fatty acids.
- Synthesis of many amino acids takes place here

Chloroplast: They are green coloured plastids which are disc shaped. The space limited by inner membrane of chloroplast is called as stroma. Stroma has organised flattened membranous sacs called the thylakoids. Thylakoids are arranged in stacks called grana. Matrix of a chloroplast contains DNA, RNA, ribosomes and enzymes. Chloroplast is also a semiautonomous organelle.

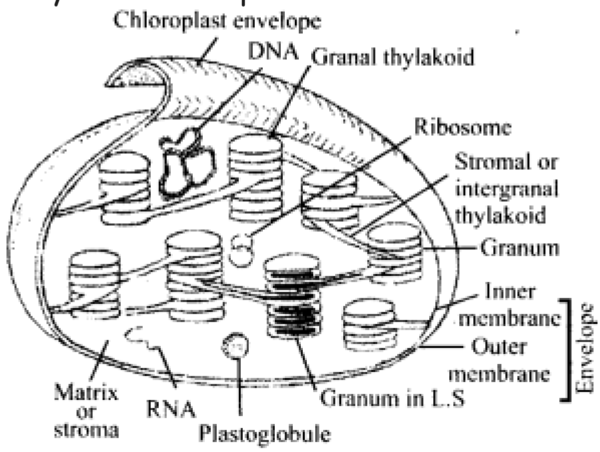


Fig.: 3-dimensional structure of a chloroplast.

Functions of chloroplast:

1. Photosynthesis is performed by chloroplast.
2. Chloroplast stores starch grains.
3. Maintains balance of C02 concentration in the air.
4. Keeps oxygen balance constant in atmosphere by liberating 02 into the atmosphere, used during respiration and combustion.

8.What are the characteristics of prokaryotic cells?

Solution: Characteristics of prokaryotic cells are as follows:

- The prokaryotic cell is essentially a single – envelope system.
- Prokaryotes lack membrane bound cell organelles.
- Prokaryotes have 70S ribosomes.
- DNA is naked and lies coiled in cytoplasm. It is not covered by nuclear membrane and is termed as nucleoid.

- Nuclear components, like, nuclear envelope, nucleolus, nucleoplasm are absent.
- Cell wall is present in bacteria and cyanobacteria, but absent in mycoplasma.
- Multiplies by asexual reproduction.
- Transcription and translation takes place in cytoplasm.

9.Multicellular organisms have division of labour. Explain.

Soln. Division of labour is differentiation of certain components or parts to perform different functions for increased efficiency and higher survival. Multicellular organisms often possess millions of cells. Various cells are grouped together to form specific tissue, organ or organ system, with each specialised to perform particular function. Every cell of a multicellular organism cannot obtain food from outside. The organism requires a system for obtaining food, its digestion and distribution. Therefore, a digestive system and system of transport are also required. Certain cells of the body take over the function of reproduction. Others take part in repair and replacement of worn out or injured portions. For optimum functioning of cells, a multicellular organism also requires an internal favourable environment. Therefore, multicellular organisms come to have division of labour.

10.Cell is the basic unit of life. Discuss in brief.

Soln. Cell is fundamental, structural and functional unit of life, as no living organism can have life without being cellular. All life begins as a single cell. An organism is either made of single cell (unicellular) or many cells (multicellular). In unicellular organism, single cell is capable of independent existence and perform all essential functions of life, while in multicellular organism, each group of cells is specialised for specific function. Life passes from one generation to the next in form of cells, and new cell always arise from division of pre-existing cells. Cells are totipotent, i.e., single cell has ability to form whole organism. The activities of an organism are sum total of activities of its cells, therefore, cell is the basic unit of life.

11.What are nuclear pores? State their function.

Soln. Nuclear envelope bounds the nucleus from outside and separates it from cytoplasm. It consists of two membranes, with outer membrane continuous with endoplasmic reticulum. The nuclear envelope is interrupted by minute nuclear pores, at a number of places, which are produced by the fusion of its two membranes. These nuclear pores are the passages through which movement of RNA and protein molecules takes place in both directions between the nucleus and the cytoplasm.

12.Both lysosomes and vacuoles are endomem-brane 'structures, yet they differ in terms of their functions. Comment.

Soln. Organelles of endomembrane system such as lysosome and vacuoles function in close coordination with one another but are specialised to perform different functions. Lysosomes breakdown the ageing and dead cells, they help in digestion of food as they contain hydrolytic digestive enzymes. They are involved in cell division also. Vacuoles on other hand, help in excretion and osmoregulation in Amoeba (contractile vacuole) or provides buoyancy, mechanical strength in prokaryotes (air vacuoles).

13.Describe the structure of the following withthe help of labelled diagrams. (i) Nucleus (ii) Centrosome

Soln.(i) Nucleus: Nucleus is double membrane bound principle cell organelle which contains all genetic information for controlling cellular metabolism and transmission of genetic information.

Nucleus is differentiated into following four parts:

(a) Nuclear envelope: It is a double membrane bound envelope that surround the nucleus and separates the latter from the cytoplasm.

(b) Nucleoplasm: Itis clear, non-staining, fluid material present in the nucleus, which contains raw materials (nucleotides), enzymes (DNA/RNA polymerases) and metal ions for the synthesis of RNAs and DNA. The nuclear matrix or the nucleoplasm is composed of nucleolus and chromatin.

(c) Nucleolus: It is a naked, round and slightly irregular structure, which is attached to the chromatin at a specific region. It is a site for active ribosomal RNA synthesis.

(d) Chromatin : It has the ability to get stained with certain basic dyes. It is known to be the hereditary DNA protein fibrillar complex. The chromatin fibres are distributed throughout the nucleoplasm.

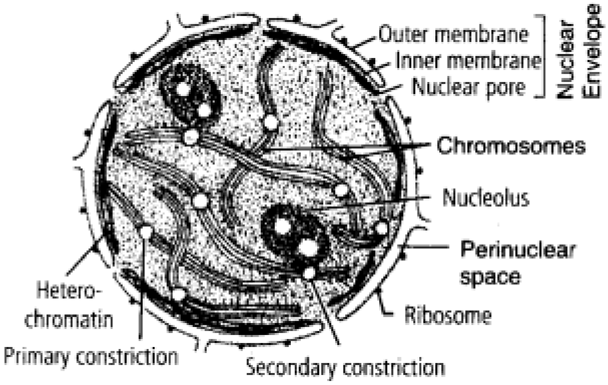


Fig : Nucleus

(ii) Centrosome: Centrosome is an organelle usually containing two cylindrical structures called centrioles. They are surrounded by amorphous pericentriolar materials. Both the centrioles in a centrosome lie perpendicular to each other. They are made up of nine evenly spaced peripheral fibrils of tubulin protein. Each of the peripheral fibril is a triplet. The adjacent triplets are also linked. The hub of centriole is connected with tubules of the peripheral triplets by radial spokes made of protein.

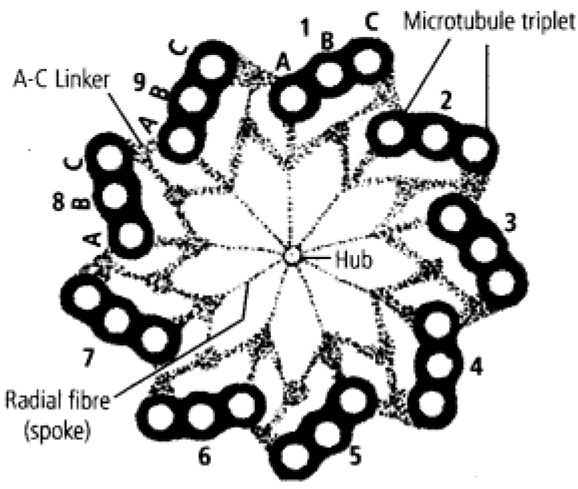


Fig : T. S. of centriole

14. What is a centromere? How does the position of centromere form the basis of classification of chromosomes. Support your answer with a diagram showing the position of centromere on different types of chromosomes.

Soln. A chromosome consists of two identical halves, the chromatids held together at one point called the centromere. The centromere is also called as primary constriction. On its side a disc shaped structure called kinetochore is present. Chromosomes are classified into four types according to position of centromere on the chromosome.

(i) Metacentric chromosome: In this chromosome, centromere is in the middle and the two arms are almost equal in length.
(ii)Submetacentric chromosome: The centromere is slightly away from middle point so one arm is slightly shorter than the other.
(iii)Acrocentric chromosome: The centromere is near the end and one arm is extremely short and other arm is extremely long.
(iv)Telocentric chromosome: Centromere is at the tip of chromosome. These chromosomes are not present in humans.

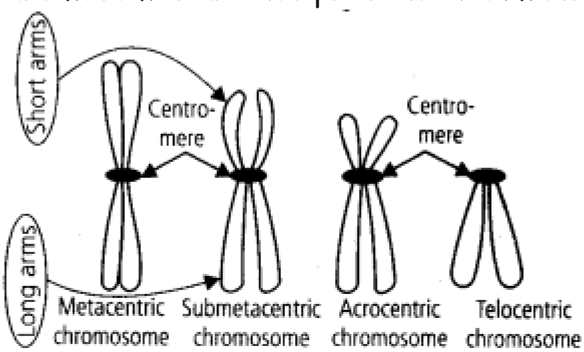


Fig : Types of chromosomes

Biomolecules Class 5 Notes Biology Chapter 9

A cell is composed of variety of molecules (like carbon, hydrogen, oxygen) which perform various functions.
Other than these basic elements, some metals and non-metals are also present as cellular materials, thence, all these materials combines in different ways in order to form various biomolecules, which are found in cells of organisms.
These molecules are not living, but perform various living functions. Thus, biomolecules are the organic substances (e.g., Carbohydrates, proteins, lipids, etc.) that play a major role in the structure and function of the living organism.
Water is also an important and most abundant chemical compound present in the body of living organism.

Topic 1 Analysis of Basic **Units of Biomolecules**

Chemical Analysis & Cyanic Compounds
To analyse the chemical composition of any organic compound in a living organism, the chemical analysis of living tissue is done. As organic compounds play a major role, it is essential to have knowledge of their molecular formula and structure.

This can be easily predicted out by performing following steps
(i) Weight of a living tissue (like a piece of a liver, fruit, vegetable or any other body tissue) is taken.
(ii) The tissue is then grinded in trichloroacetic acid (Cl_3CCOOH) with the help of mortar and pestle.
(iii) The thick slurry obtained is then filtered through a cheese-cloth or cotton.

This will generate two fractions of solution
(a) Filtrate or the acid-soluble fraction.
(b) Retentate or the acid-insoluble fraction.
(iv) The extract can then be subjected to numerous separation techniques, in order to obtain the desirable compound from all other components.

By successfully performing all the above steps, we can get an idea of the molecular formula and the probable structure of the compound.

(v) All the carbon compounds that we get from living tissues can be called biomolecules.

Ash Analysis for Inorganic Compound and Elements
After the analysis of chemical composition of an organic compound in a tissue, it is necessary to do the analysis of inorganic elements and compounds. It can be done easily by performing a destructive experiment that separate inorganic compounds from organic compounds in the form of ash (contains inorganic compounds and elements).
Ash is the remaining part of apy living tissue which remains back after burning of all organic compounds.

Ash analysis is done in order to analyse the chemical composition of different inorganic compounds and elements. It is done in the following way
(i) For analysis, a small amount of a living tissue is taken, which is oven dried till all the water evaporates.
(ii) This gives the dry weight.
(iii) After that tissue is burnt completely which results in the formation of ash. Thus, ash formed contains inorganic elements like potassium, sodium, calcium, magnesium, etc (inorganic compounds are also seen in the acid soluble fraction).

Cellular Pool
The sum total of different types of biomolecules, compounds and ions present in the cell is called cellular pool. It contains more than 5000 chemicals.
List of Representative Inorganic Constituents of Living Tissues
Components Formula

Components	Formula
Sodium	Na^+
Potassium	K^+
Calcium	Ca^{2+}
Magnesium	Mg^{2+}
Water	H_2O
Compounds	$NaCl$, $CaCO_3$, PO_4^{3-}, SO_4^{2-}

Biomicromolecules

Biomicromolecules are small in size, with low molecular weight (18-1800 Da) highly soluble (if polar) and have simple molecular conformation. Micromolecules can be inorganic such as water, minerals salts, gases or organic compounds such as sugars, amino acids, nucleotides, etc.

All these compounds mentioned above are soluble fraction of filtrate except the lipids which occur as insoluble fraction of filtrate as they are mosdy found in cell membrane and thereby forms vesicles, which are separated as an insoluble pool.

Various micromolecules in detail are as follows

1. Carbohydrates

These are the organic compound mainly made up of C, H and O. They are defined as polyhydroxy aldehydes and ketones. These are produced directly by the plants during photosynthesis. Carbohydrates are also known as saccharides because their major constituents are sugars.

These are divided into following types

i- Monosaccharides

These are simplest carbohydrates which cannot be hydrolysed further into smaller components. These are generally composed of three to seven carbon atoms per molecule.

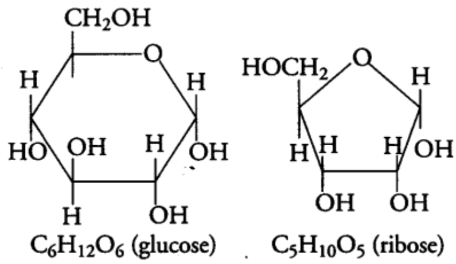


Fig. 9.1 Sugars (carbohydrates)

Monosaccharides are also known as reducing sugars, because they have a free aldehydic (—CHO) or ketonic (> C = O) group and can also reduce Cu2+ (cupric ions) of Benedict's or Fehling's solution to Cu+ (cuprous ions)., e.g., Ribose, glucose, erythrose, etc.

1. Oligosaccharides

These are formed by condensation of 2-6 monosaccharide molecules. The bond between two monosaccharide units is called a glycosidic bond.

They are classified according to the number of their monosaccharide units or monomers as follows

(a) Disaccharides These are the sugars containing two monomeric units and can be further hydrolysed into smaller components. These are known as non-reducing sugars because the free aldehyde or ketone group is absent, e.g., Sucrose, maltose, lactose, etc.

(b) Trisaccharide It contain three monomers. e.g., Raffinose.

(c) Tetrasaccharides, e.g., Stachyose and so on.

2. Amino Acids

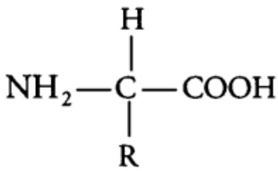
Amino acids are organic compounds containing an amino group and an acidic group as substituent on the same carbon, i.e., the a-carbon. Hence, they are called a-amino acids. These are substituted methanes.

a-carbon also bears a hydrogen and a variable group designated as R group. Thus, there are four substituent

groups present on a-carbon which occupy the four different valency position. These are hydrogen, carboxyl, amino and R group.

Based on the nature of R group, there are many amino acids. However, those which occur in proteins are only of twenty types.

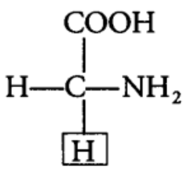
General formula of α-amino acid is given below as



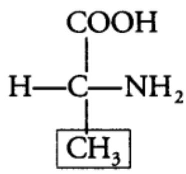
where, R = side chain of amino acids

The amino group accepts a proton whereas, the carboxyl group donates a proton. So, an amino acid can act as both acid and base. Hence, it is amphoteric in nature. The R group in these proteinaceous amino acids could be a hydrogen (glycine), a methyl group (alanine), hydroxyl methyl (serine), etc.

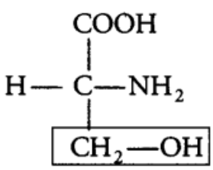
e.g.,



Glycine



Alanine



Serine

Fig. 9.2 Amino acids

The chemical and physical properties of amino acids are essentially due to the amino, carboxyl and functional groups present.

Based on the number of amino and carboxyl group present, amino acids are categorised into following types

i. Acidic Amino Acids

These contain one amino group and two carboxyl group per molecule, e.g., glutamic acid and aspartic acid.

ii. Basic Amino Acids

These contain two amino groups and one carboxyl group per molecule, e.g., Arginine, lysine and histidine.

iii. Neutral Amino Acids

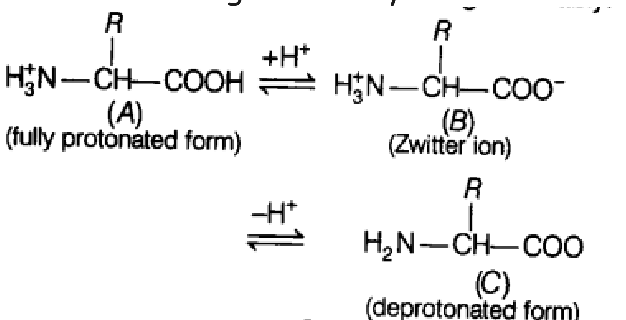
These contain one amino group and one carboxyl group per molecule, e.g., Methionine, isoleucine, serine, threonine, cysteine, glycine, alanine, valine, leucine, aspargine, glutamine and proline.

iv. Aromatic Amino Acids

These contain aromatic rings in their side chain, e.g., Phenylalanine, tyrosine and tryptophan.

Zwitter Ion

Zwitter ion formation is anoth'er particular property of amino acid. It is a neutral molecule (with positive and negative charge), having the ionizable nature of —NH_2 and —COOH groups. Hence, in splutions of different pHs, the structure of amino acid changes variably.



Representations of a Zwitter ion formation

3. Lipids

Lipids are the esters of fatty acids and alcohol. These are generally insoluble in water. They could be simply fatty acids.

Fatty acids are the organic acids having hydrocarbon chains that end in a carboxylic group (—COOH). The carboxylic group is attached to an R group that could be a methyl (—CH_3) or ethyl (—C_2H_5) or higher number of —CH_2 groups (1 carbon to 19 carbons), e.g., Palmitic acid has 16 carbons including carboxyl carbon. Arachidonic acid has 20 carbon atoms including the carboxyl carbon.

Depending upon the types of bonds present, fatty acids are of following two types

i.Saturated Fatty Acids

Fatty acids which do not have double bonds, (C—C). These are generally solid at room temperature.

ii. Unsaturated Fatty Acids

Fatty acids which contain one or more than one double bonds (C = C). These are generally liquid at room temperature.

$$CH_3 - (CH_2)_{14} - COOH$$

(Palmitic acid)

(a)

$$CH_3(CH_2)_7\ CH = CH\ (CH_2)_7\ COOH$$

(Oleic acid)

(b)

Fig. 9.3 Fatty acids (*a*) Saturated (*b*) Unsaturated

Difference between saturated and unsaturated fatty acids

Saturated Fatty Acids	Unsaturated Fatty Acids
Do not possess any double bond in their carbon chains.	Possess one or more double bonds in their carbon chains.
Solid at room temperature.	Liquid at room temperature.
Occur in most animal fats.	Occur in most plant fats.
Relatively higher melting point.	Relatively lower melting point.
e.g., Palmitic acid, stearic acid.	*e.g.*, Oleic acid, linoleic acid.

Simple Lipids

These are esters of fatty acids and various alcohol.

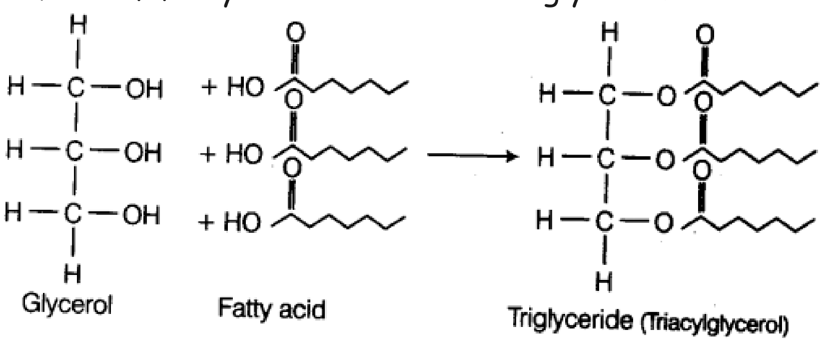
They are of further two types

(a) Neutral or True Fats These are esters of fatty acids with glycerol (glycerine). They are also called glycerides.

Glycerol is a simple lipid which is known as trihydroxypropane as it is an alcohol with a backbone of three carbon atoms, each carrying an —OH group.

When glycerol is esterified with fatty acid it is known as triglyceride.

The ester is called monoglyceride, diglycerlde and triglyceride depending on the number of fatty acids attached to a glycerol.



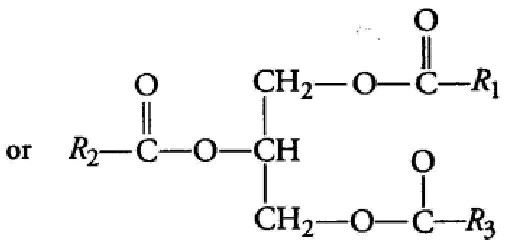


Fig. 9.4 Triglyceride *R_1, R_2 and R_3 are fatty acids)*

ii- Compound or Conjugated Lipids

These are the esters of fatty acids and alcohol but contain other substances also, e.g., Phospholipids, glycolipids, cutin, suberin etc.

Phospholipids are lipids which have phosphorus and phosphorylated organic compound in them. One of the common example of phospholipid is lecithin. Some tissue have complex structure of lipids, e.g., Neural tissues.

(b) Oils are usually liquid at room temperature because they have low melting point, e.g., groundnut (peanut) oil, cotton seed oil, mustard oil, etc.
As oils have low melting points. They remain as oils in winters also, e.g., Gingely oil.

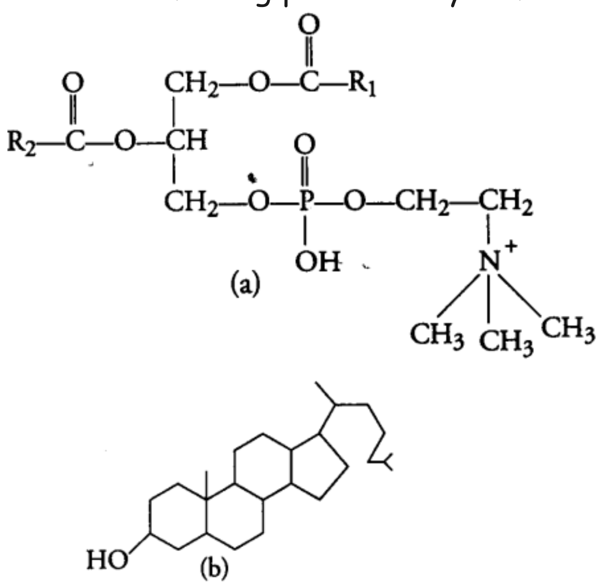


Fig. 9.5 Compound lipids (a) Phospholipid (lecithin)
(b) Cholesterol

iii. Derived Lipids

These are lipid-like substances such as sterol or derivatives of lipids, e.g., steroids, prostaglandins and terpenes.
Fats are also differentiated into two main types, on the basis of their melting points at room temperature as follows
(a) Hard Fats are solids at room temperature and contain long chains of fatty

acids, e.g., Animal fat.
Softness of butter is due to the good quantity of short chain fatty acid it contains.

4. Nucleotides
These are the monomers of nucleic acids.The nucleotides are made up of three molecules, i.e., a pentose sugar, a cyclic nitrogenous base and a phosphoric acid (phosphate group), e.g., Adenylic acid, thymidylic acid, guanylic acid, uridylic acid and cytidylic acid.

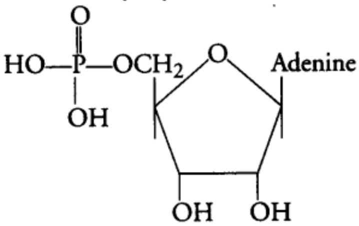


Fig.9.6 Nucleotide (adenylic acid)

1. Pentose Sugar
It occurs in pentagon or fiiranose form with four carbon and one 02 forming a ring. It is present in the form of ribose or deoxyribose sugar in RNA and DNA respectively.
i. Nitrogenous Bases
These are the flat heterocyclic compounds having nitrogen and carbon in ring structure.

These are of basically two types
(a) Purines It is larger and composed of two rings. They are further of two types, i.e., Adenine (A) and Guanine (G).
(b) Pyrimidines It is smaller and composed of single ring. They are of further three types, i.e., Cytosine (C), Thymine (T) and Uracil (U).

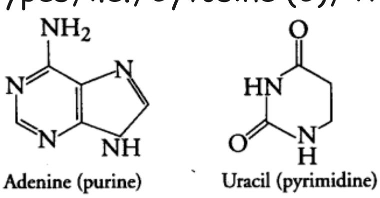


Fig. 9.7 Nitrogen bases

iii. Phosphoric Acid (Phosphate Group)
It is composed of phosphoric acid. A nucleotide may have 1, 2 or 3 phosphate groups. It gives acidic nature to the nucleotide.

Nucleoside

If a pentose sugar is attached to a nitrogen base by a glycosidic bond, it is called nucleoside.
e.g., adenine + ribose —> adenosine.
Likewise guanosine, thymidine, uridine and cytidine are the examples of nucleoside.
The nucleoside combines with a phosphate group at 5-position by an ester bond to form a nucleotide.

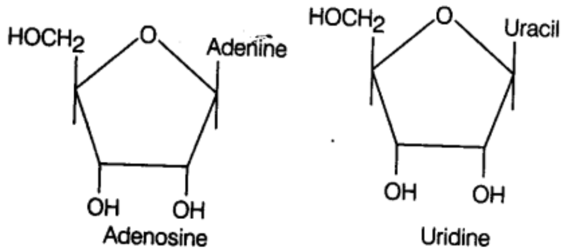


Fig. 9.8 Nucleosides

Differences between Nucleoside and Nucleotide

Nucleoside	Nucleotide
It is a compound formed by the combination of a nitrogen base with a pentose sugar.	It is a compound formed by the combination of a nitrogen base, pentose sugar and a phosphate group.
It is a component of a nucleotide.	Components of nucleic acids (formed by phosphorylation of a nucleoside).
Slightly basic in nature.	Acidic in nature.
e.g., Guanosine, adenosine, etc.	*e.g.*, Guanylic acid, adenylic acid, etc.

Primary and Secondary Metabolites

A large number of organic biomolecules are present in the cells which are used in various metabolic reactions of cell. Hence, these compounds are called metabolites. These are divided into two types

1. Primary Metabolites

These are metabolites which are found in animal tissues. Their functions are easily indentifiable. They play specific known roles in the normal physiological processes, e.g., Amino acids, carbohydrates, proteins, nitrogen bases, nucleic acids, etc.

2. Secondary Metabolites

These are metabolites which are generally found in plant, fungal and microbial cells.

These are the products of certain metabolic pathways. Their functions are not identifiable in host organism and are not yet understood, e.g., Alkaloids, flavonoids, rubber, essential oils, antibiotics, coloured pigments, scents, gums, spices.

Some Secondary Metabolites

Pigments	Carotenoids, Anthocyanins, etc
Alkaloids	Morphine, codeine, etc.
Terpenoides	Monoterpenes, diterpenes, etc.
Essential oils	Lemon grass oil, etc.
Toxins	Abrin and ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin, etc.
Polymeric substances	Rubber, gums and cellulose

Note:

- Nucleic acids (DNA and RNA) are composed of only nucleotides, both DNA and RNA acts as a genetic material.
- Uracil is found only in RNA in place of thymine.
- Ribose molecule differs from deoxyribose molecule in having a -OH group instead of H at carbon 2.
- Heterocyclic compounds have more than one kind of atoms.

Functions

Both primary and secondary metabolities serves the followingjunctions
(i) Many of them are useful in human welfare, e.g., Rubber, drugs, spices, scents, pigments.
(ii) Some have ecological importance.

Topic 2 Biomacromolecules

Biomacromolecules are large in size, higher molecular weight molecules 10,000 daltons (Da) and above (except lipids).
These are generally formed by linking a number of micromolecules commonly known as monomers.

All these compounds are found in the acid insoluble pool. These are of four major types, i.e., proteins, polysaccharides, nucleic acids and lipids.

Except lipids all other macromolecules are formed by polymerisation (condensation) of monomeric subunits.

The molecules which are found in living organisms are divided into two main types
(i) Biomicromolecules These are molecules which have their molecular weight less than 10,000 Da.
Biomicromolecules has already been described in detail in topic 1 of the chapter. .

(ii) Biomacromolecules These are molecules which have their molecular weight, 10,000 Da and above.
All these macromolecules are actually polymers of their biomicromolecules.
For example, Polysaccharides are polymers of monosaccharides, proteins are polymers of amino acids and nucleic acids are polymers of nucleotides.

Hence, on the basis of the number and types of monomer present, polymers are of following two types
(i) Homopolymers, are those which have only one type of monomer present. These monomer can be repeated n number of times in a chain, e.g., Starch, insulin, etc.
(ii) Heteropolymers, are those which have two or more than two types of monomers, e.g., Proteins.Various macromolecules and their major roles are described under as

Lipids
The molecules in the insoluble fraction are polymeric substances except lipids. Athough lipids have their molecular weight not exceeding above 800 Da, but still it comes under acid insoluble fraction, i.e., biomacromolecular category.

This happens because these are small moleculer weight compounds and are present not only as such, but also arranged in structures like cell membranes and other membranes.

Thus, when we grind a tissue, we disrupt the cell structure, cell membrane and other membranes are broken down into pieces and form vesicles that are not water soluble. Therefore, these are separated along with acid insoluble pool and are placed in macromolecules.

Lipids are not strictly biomacromolecule.
If representation of the chemical- composition of living tissue is done from abundance point of view and arranged class-wise, it is observed that water is the most abundant chemical in living organisms.

Average Composition of Cells
i. Primary Structure
It is the description of basic structure of a protein. This includes number and sequence of amino acids in each polypeptide. The distance between two adjacent peptide bonds is about 0.35 nm.
A protein is imagined as a line whose left end is represented by the first amino acid, also called as the N-terminal amino acid and the right end is represented by the last amino acid called the C-terminal amino add, e.g., Insulin, ribonudease.

Component	% of the Total Cellular Mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	2
Nucleic acids	5-7
Ions	1

Proteins

These are the most important and abundant intracellular organic biomoLecules. These are polypeptides having chains of amino acid arranged linearly that are linked by peptide bonds.
Thus, each protein is a polymer of amino acids (as studied earlier in the chapter), there are 20 types of amino acids, e.g., Alanine, valine arginine, leucine, histidine, etc.

So, proteins are considered as heteropolymer.

These amino acids are divided into two main types, on the basis of their utility
(i) Essential Amino Adds These are those amino acids that are essential for our

health so, are need to be supplied through our diet. The dietary proteins are the source of essential amino acids, e.g., Leucine, isoleucine, etc.

(ii) Non-essential Amino Adds These are those amino acids, which our body can synthesise, e.g., Proline, serine.
Human adults require an additional essential amino acid named threonine while children need two more arginine and histidine. These are. called semi-essential amino acids.

Structure of Proteins
As mentioned earlier, proteins are heteropolymers containing strings of amino acids. Biologists describe the protein structure at four different levels, i.e., primary, secondary, tertiary and quaternary.

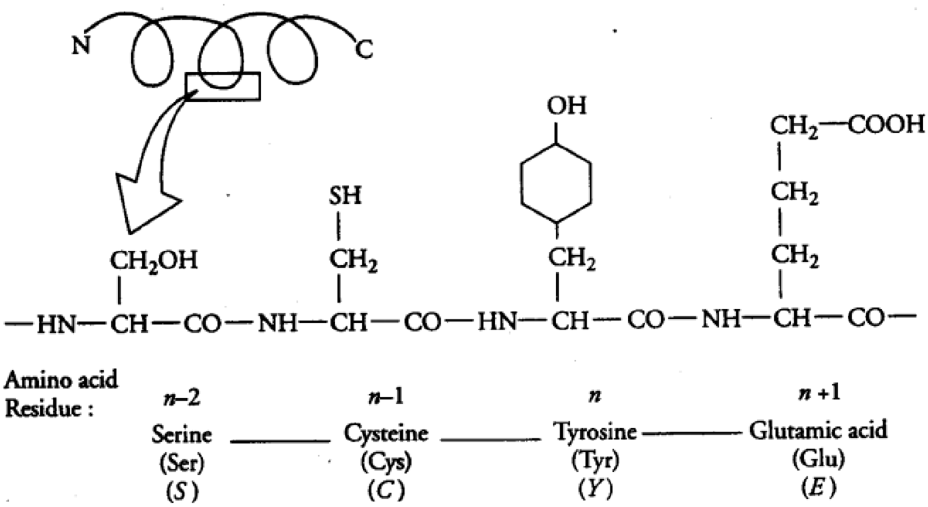


Fig. 9.9 Primary structure of a portion of a hypothetical protein. N and C refer to the two termini of every protein. Single letter codes and three letter abbreviations for amino acids are also indicated.

ii. Secondary Structure
The thread of the primary protein is folded in the form of a-helix. The a-helix is stabilised by hydrogen bonds between oxygen of the carboxylic group of one amino acid residue and —NH group of the next fourth amino acid residue, e.g., Keratin.

In β-pleated secondary structure, two or more polypeptide chains get interconnected by hydrogen bonds. Adjacent strands of polypeptide may run in the same direction or in opposite direction, e.g., Silk fibre.

In proteins, only right handed helices are observed.The polypeptide chain curls The protein is more distended and longitudinally by the action of the hydrogen bond forms a zig-zag hydrogen bonds forming a shaped protein structure called spiral or helix. (which combines and forms p-sheet).

Differences between α-helix and β-pleated Structure of Proteins

α-helix Structure	β-pleated Structure
The polypeptide chain curls longitudinally by the action of hydrogen bonds forming a spiral or helix.	The protein is more distended and the hydrogen bond forms a zig-zag shaped protein structure called β-strand (which combines and forms β-sheet).
It is highly compact and rigid.	It is less compact and rigid.
It is always antiparallel.	It can eithe▸be parallel or antiparallel.

iii. Tertiary Structure

There is bending and folding of various types to form a hollow wollen ball-like spheres, rods or fibres. Tertiary structure is stabilised by several types of bonds- hydrogen bonds, ionic bonds, van der waals interactions, covalent bonds and hydrophobic bonds. It gives information about a 3-dimensional (3-D) conformation of the protein, e.g., Myoglobin.

Tertiary structure is helpful for many biological activities of proteins.

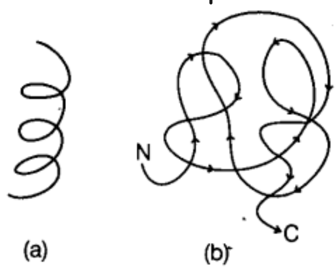


Fig. 9.10 Diagram showing
(a) A secondary structure
(b) A tertiary structure of proteins

iv. Quaternary Structure

Certain proteins consist of an asembly of more than one polypeptide or subunits. Thus, the individual polypeptide or subunit are arranged with respect to one another (linear strings of spheres, spheres arranged one upon each other in the form of a cube or plate, etc.) e.g., Haemoglobin, lactic acid dehydrogenase enzyme. This type of structure is found only in the oligomeric proteins (proteins having two or more polypeptide chains).

Structure of Haemoglobin (Hb)

An adult human haemoglobin is a iron containing pigment that acts as an oxygen

carrier. It has a quaternary structure because it is made up of four monomeric sub-units each about the size of many normal individual proteins.
Every subunit has its own tertiary structure and is identical to each other. Hence, two subunits of α-type and two sub-units of β-type together constitute the human haemoglobin (Hb). Insulin is an another example of protein having quaternary structure.

Types of Proteins
Proteins are classified on the basis of shape, chemical composition and function.
Accordingly on the basis of shape these are of two main types
i. Fibrous Proteins
The proteins have spiral secondary polypeptide chains wound around each other in order to form fibres. These are insoluble in water generally, but soluble in concentrated acids, alkalis and salts, e.g., Collagen of connective tissue, keratin of hair, etc.

ii. Globular Proteins
They are rounded in shape and are generally soluble in water and in dilute acids, alkalis, salts, e.g., Egg albumin, serum globulins.

Note:
Collagen, the most abundant protein of animal world and Ribulose Bisphosphate Carboxylase Oxygenase (RuBisCO) is the most abundant protein in plants and the whole of the biosphere.
Functions of Proteins
Proteins have various basic functions in living organism given below . Helps in transportation of nutrients across the cell membrane by acting as protein transporter.
(ii) Helps in fighting with infectious organism.
(iii) These are helpful in movement of muscles, e.g., Myosin and actin.
(iv) Helps in maintenance of pH and regulation of the volume of body fluids.
(v) Helps at the time of injury in blood clotting and acts as antibodies and provide immunity.
(vi) Helps in growth and repair of body tissues.
(vii) Some proteins function as hormones and some functin as enzymes and catalyse the reactions.

Denaturation of Proteins
When proteins are exposed to extreme change in pH, acids or temperature (or bases or high salt concentrations) the weak bonds holding the tertiary and the quaternary structure gets disrupted so, that the protein unfold (into primary structure). This unfolding is known as denaturation of proteins or loss of its functioning.
Denaturation is not strong enough to break peptide bonds thus, primary structure remains unaffected.
A denatured protein may spontaneously refold into its original structure when suitable condition are re-provided. This is called renaturation.

Polysaccharides

These are another class of macromolecule that are present in the acid insoluble fraction. Polysaccharides are long chains of sugars. They are not sweet and are insoluble in water. Polysaccharide chain (like glycogen) is made up of two ends, whose right end is called reducing end and the other left end is called non-reducing end. They- ace threads containing different monosaccharides as building blocks.

Types of Polysaccharides
Polysaccharides are of two types as given below
i. Homopolysaccharides
These are those complex carbohydrates which are formed by polymerisation of only one type of monosaccharide monomers, e.g., Starch, glycogen and cellulose (these all are composed of single type of monosaccharide unit namely glucose).

Some of them are as fallows
a. Cellulose
It is a polymeric polysaccharide which consists of only one type of monosaccharide monomer, i.e., glucose. It is known to be a rigid and insoluble polysaccharide found in cell wall of most algae, certain protists, fungi and some higher plant.

Paper made from pulp of plant and cotton fibre are also made up of cellulose. As cellulose is not composed of complex helices so, it cannot hold iodine (I_2) and cannot give colour with iodine.

b. Starch
It is a storage polysaccharide because it helps in storing energy in plant tissues.

Chemically, the starch is formed of two glucose monomers, r.e.,a-amylose and amylopectin.

Starch forms helical secondary structures. Thus, it can hold iodine (I_2) molecules in the helical portion. Therefore, gives blue colour with iodine solution.

c. Glycogen

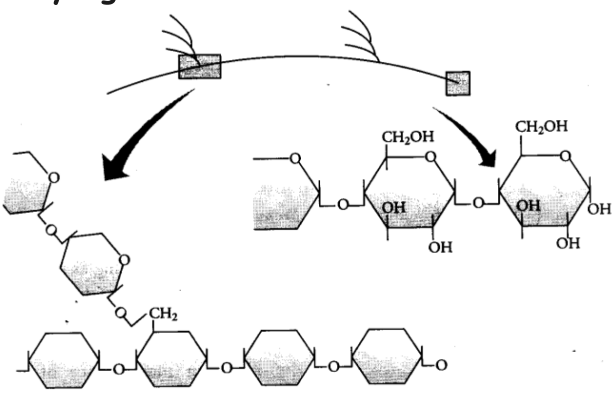


Fig. 9.11 Diagrammatic representation of a portion of glycogen

It is also storage polysacchiaride found in animals only (in liver cells and muscles). It is also known as animal starch. It gives red colour on reaction with iodine.
It is a polymer of fructose. It is a naturally occurring polysaccharide produced by many types of plants. It is used by some plants in storing energy.

Plants that synthesis and store inulin are unable to store other forms of carbohydrates like starch, etc.
Agar, xylan, araban, etc, are some other types of homopolysaccharides found.

ii. Heteropolysaccharides
These are complex carbohydrates formed by the polymerisation of two or more than two types of monosaccharide monomers, e.g., Chitin, pectin, peptidoglycans (murein), hyaluronic acid.

iii. One ofthem is explained below Chitin
It is the second most abundant natural polymer, found in exoskeleton of arthropods (e.g., prawns, crabs, etc.) and in cell wall of fungi. It has building blocks of amino sugars and chemically modified sugar.

iv. acetylglucosamine units interlinked by glycosidic bond
Glucosamine also acts as building block (like N-acetyl glucosamine) in other types of heteropolysaccharide.

Functions of Polysaccharide
Polysaccharide plays multiple function and can be used in the following ways
(i) Acts as structural compounds in cell wall of plants certain fungi and protists, e.g., Cellulose, chitin.
(ii) Helps in anticoagulation and prevents blood clotting inside the vessels, e.g., Heparin.
(iii) Helps in lubrication of joints between bones, e.g., Hyaluronic acid.
(iv) Also used in tissue culture, e.g. Agar.
(v) Acts as a reserve food, e.g., Starch.

Nucleic Acids
The other type of macromolecule found as a part of acid insoluble fraction of any living tissue is the nucleic acids. These are polymeric compounds of nucleotides, i.e., polynucleotides.
A nucleotide (as discussed previously in the chapter) is composed of three chemically distinct components
(i) Heterocyclic compound-nitrogen base (adenine, guanine, uracil, cytosine and thymine).
(ii) Monosaccharide (ribose or deoxyribose).
(iii) Phosphoric acid or phosphate.
A nucleic acid which contains deoxyribose sugar is called deoxyribonucleic acid (DNA), while that which contains ribose sugar is ribonucleic acid (RNA).

Deoxyribonucleic Acid (DNA)
DNA is genetic material found in the nucleus of all living cells except some viruses. In eukaryotic organisms linear DNA is found in nucleus, in the mitochondria and chloroplasts, whereas in prokaryotes, DNA is circular in structure and is found in the cytoplasm.

Structure of DNA
The structure of DNA was elucidated by Watson and Crick based on X-ray diffraction studies. They proposed a double helix model of DNA. According to this model, DNA exists as a double helix and consists of two strands of polynucleotides that are antiparallel to each other, i.e., both run in opposite directions, one in 5'–>

3' direction and other in 3'—> 5'direction. ,

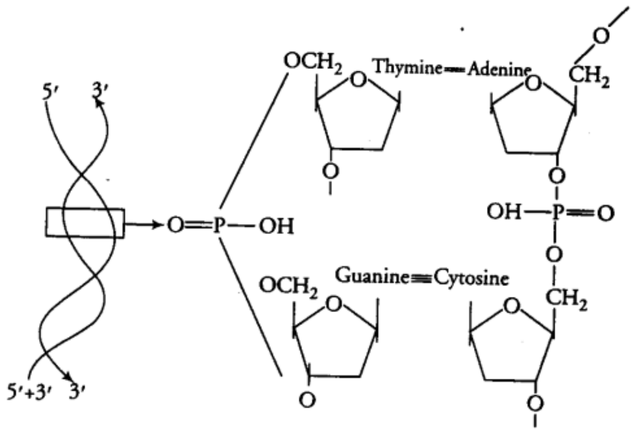


Fig. 9.12 Diagram indicating secondary structure of DNA

The backbone of DNA is formed by the sugar phosphate-sugar chain. The nitrogen bases are projected more or less perpendicular to the backbone of DNA and faces inside. A and G of one strand base pairs with T and C respectively on the other strand.

Between A and T (A== T), there are two hydrogen bonds while, there are three hydrogen bonds between G and C(G=C).

DNA has a uniform thickness of 20 A and pitch of is 34 nm. Thus, one turn of DNA measures 3.4 nm (rise per base pair) and consists of 10 nucleotides (or ten base pairs). This form of DNA is called B-DNA.

Functions of Nucleic Acids

Nucleic acidplays multiple role in living organism these are given as follows

(i) It enables cell to grow, maintain and divide by directing the synthesis of structural proteins.

(ii) Acts as a genetic material, i.e., transfer hereditary characters from one generation to the next.

Differences between DNA and RNA are given below

Deoxyribonucleic Acid (DNA)	Ribonucleic Acid (RNA)
Found in chromosomes of the nucleus.	Found in the cytoplasm, in nucleolus and nucleoplasm and associated with chromosomes.
Double-stranded structure; two strands coiled spirally in opposite direction.	Single-stranded polynucleotide chains; strand in RNA is coiled on itself and may be united by hydrogen (H) bonds.
The sugar is deoxyribose.	The sugar in ribose.
Four nitrogenous bases in it are (*i*) Adenine, (*ii*) Guanine } Purine (*iii*) Cytosine, (*iv*) Thymine } Pyrimidine	*Four nitrogenous bases in it are* (*i*) Adenine, (*ii*) Guanine } Purine (*iii*) Cytosine, (*iv*) Uracil } Pyrimidine *i.e.*, in RNA, thymine is replaced by uracil.
Purines and pyrimidines occur in equal proportion.	Do not occur in equal proportion/ratio.
DNA is the hereditary material.	It takes part in protein synthesis.
Controls structure, metabolism, differentiation and inheritance.	Helps in protein synthesis; function as a messenger and translates messages coded in DNA into protein.
Long molecule with high molecular weight	Relatively short molecule with low molecular weight.
Genetic material in all prokaryotic and eukaryotic cells.	Genetic material only in some viruses.
It does not occur in different types.	*It occurs in three different types* (*i*) *m*RNA (*ii*) *t*RNA (*iii*) *r*RNA

Some of them are as follows

1. Peptide Bond

In a polypeptide or a protein, amino acids are linked by a peptide bond. Formed when the carboxyl group (—COOH) of one amino acid reacts with the amino group (—NH_2) of the next amino acid with elimination of water.

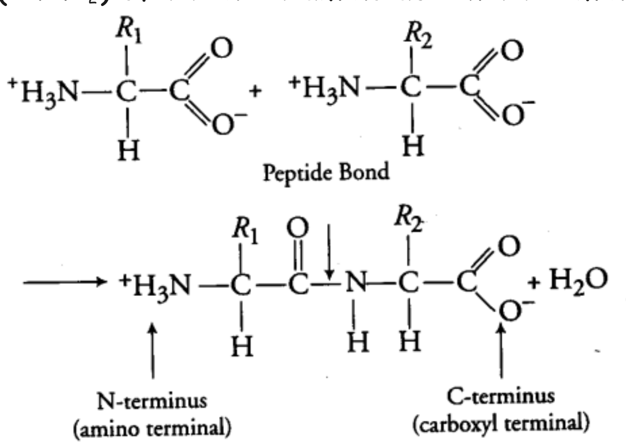


Fig. 9.13 Formation of a peptide bond

2. Glycosidic Bond
It is formed between two carbon atoms of two adjacent monosaccharides, thus it forms a polysaccharide by linking individual monosaccharides. This bond is also formed by dehydration (removal of water).

3. Phosphodiester Bond
In a nucleic acid a phosphate moiety links the 3,carbon of one sugar of one nucleotide to the 5'carbon of the sugar of the succeeding nucleotide.
The bond between the phosphate and hydroxyl group of sugar is an ester b id. As there is one such ester bond on either side, it is called phosphodiester bond.

Dynamic State of Body Constituents
Nature of Bond Linking Monomers in a Polymer
The polymers described above in the topic are formed by the combination or linking of one or more type of monomer units. So, in order to link these units together various types of bonds are required depending on the nature and the type of macromolecule.

Concept of Metabolism

Each cell contain thousands of organic compounds. These compounds or biomolecules are present in living organisms in various concentrations. Turn over of biomolecules is one of the greatest discoveries. It is the phenomenon in which biomolecules change constantly into some other biomolecules or made from some other biomolecules.

All these, transfer of one biomolecule into other occur due to chemical reaction which continuously take place in an organism. The chemical reactions together are called metabolism.

Each metabolic reaction results in the process of transformation, e.g., an amino acid when transforms intq an amine, CO_2 is removed, removal of amino group in a nucleotide base, etc.

Majority of these metabolic reactions do not occur in isolation, instead they take place in a series of linked reaction known as metabolic pathways. These pathways are either linear or circular and criss-cross each other, i.e., there are traffic functions.

Flow of metabolites through metabolic pathway has a definite rate and direction and this metabolic flow is called the dynamic state of body constituents. Also these metabolic reactions are always catalysed reaction, i.e., no uncatalysed metabolic conversion is present in living systems. The catalysts which hasten the rate of a given metabolic conversion are also proteins. These proteins with catalytic power are called enzymes.

Metabolic Basis for Living

Metabolic pathways in living organisms are divided into two main types

i. Anabolic Pathways

These include the formation of complex structure from simple ones, e.g., formation of cholesterol from acetic acid, protein synthesis, etc. These are energy consuming pathways.

ii. Catabolic Pathways

Glycolysis

Glucose is degraded to lactic acid in human skeletal muscle, liberating energy. This metabolic pathway from glucose to lactic acid which occurs in ten metabolic steps is called glycolysis.

This liberated energy is stored in the form of chemical bonds and this bond energy can be utilised in various biosynthetic, osmotic and mechanical work when needed.

Adenosine Triphosphate (ATP)

The most important form of energy currency present in living systems is the bond energy in a chemical compound of ATP.

The Living State

Various chemical compounds (metabolites or biomolecules) are present at a concentration characteristic of each of them, i.e., all living organisms exist in a steady state characterised by concentrations of each of these biomolecules. It is the most important fact of biological systems. These metabolites are in a state of metabolic flux. Hence, the living system is kept in a non-equilibrium state by metabolic flux, which enables it to perform work as living organism.

It has to work continuously and are unable to reach equilibrium.

Therefore, metabolism is helpful in providing a mechanism which enables energy production.

It can be stated that the living state and . metabolism are synonymous and are correlated. Thus, metabolism and living state are incomplete without each other.

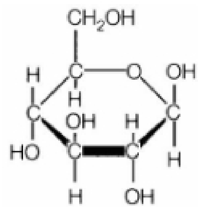
These include the formation of simpler structures, i.e., the breakage of complex structures into simpler ones, e.g., Conversion of glucose into lactic acid in skeletal muscles. These are energy releasing

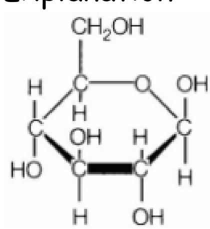
Biomolecules Class 11 MCQs Questions with Answers

Question 1.
Feedback inhibition of enzymes is affected by which of the following
(a) enzyme
(b) substrate
(c) end products
(d) intermediate end products
Answer
Answer: (c) end products
Question 2.
An example of competitive inhibition of an enzyme is the inhibition of
(a) succinic dehydrogenase by malonic acid
(b) cytochrome oxidase by cyanide
(c) hexokinase by glucose-6-phosphate
(d) carbonic anhydrase by carbon dioxide
Answer
Answer: (a) succinic dehydrogenase by malonic acid
Question 3.
Insulin is made up of ________ and ________.
(a) glucose and fructose
(b) glucose and fructose
(c) fructose and mannose
(d) mannose and glucose
Answer

Answer: (b) glucose and fructose
Explanation:
Insulin is a polysaccharide made up of glucose and fructose.
Question 4.
Enzymes increase the rate of reaction by
(a) lowering activation energy
(b) increasing activation energy
(c) increasing temperature and pH
(d) decreasing temperature and pH
Answer
Answer: (a) lowering activation energy
Explanation:
Enzymes increase the rate of reaction by decreasing the activation energy.
Question 5.
Which of the following statements regarding enzyme inhibition is correct?
(a) Competitive inhibition is seen when a substrate competes with an enzyme for binding to an inhibitor protein
(b) Non-competitive inhibitors often bind to the enzyme irreversibly
(c) Competitive inhibition is seen when the substrate and the inhibitor compete for the active site on the enzyme
(d) Non-competitive inhibition of an enzyme can be overcome by adding large amount of substrate
Answer
Answer: (c) Competitive inhibition is seen when the substrate and the inhibitor compete for the active site on the enzyme
Question 6.
Which of the following is not a pyrimidine?
(a) Uracil
(b) Cytosine
(c) Guanine
(d) Thymine
Answer
Answer: (c) Guanine
Explanation:
Guanine is a purine.
Question 7.
Hydrolysis of starch occurs with the help of
(a) Peptidase

(b) Amylase
(c) Sucrose
(d) Lipase
Answer
Answer: (b) Amylase
Question 8.
Assertion: Arachidic acid is an unsaturated fatty acid.
Reason: There are one or more double bonds between carbon atoms in unsaturated fatty acids.
(a) Both Assertion and Reason are true and Reason is the correct explanation of the Assertion.
(b) Both Assertion and Reason are true but the Reason is not the correct explanations of Assertion.
(c) Assertion is true, but Reason is false.
(d) Both Assertion and Reason are false
Answer
Answer: (d) Both Assertion and Reason are false
Question 9.
Which of the following influence feedback inhibition of enzyme?
(a) End product
(b) External factors
(c) Enzyme
(d) Substrate
Answer
Answer: (a) End product
Question 10.
Which of the following is not a polysaccharide?
(a) Lactose
(b) Starch
(c) Glycogen
(d) Dextrin
Answer
Answer: (a) Lactose
Explanation:
Lactose is a disaccharide made up of glucose and galactose.
Question 11.
Inulin is made up of ________ and ________.
(a) glucose and fructose

(b) glucose and fructose
(c) fructose and mannose
(d) mannose and glucose
Answer
Answer: (b) glucose and fructose
Explanation:
Inulin is a polysaccharide made up of glucose and fructose.
Question 12.


The structure shown above is
(a) mannose
(b) fructose
(c) glucose
(d) galactose
Answer
Answer: (c) glucose
Explanation:


Glucose molecule
Question 13.
A protein having both structural and enzymatic traits is
(a) Collagen
(b) Trypsin
(c) Myosin
(d) Actin
Answer
Answer: (c) Myosin
Question 14.
NADP contains vitamin _______.
(a) B1
(b) B2

(c) B3
(d) B12
Answer
Answer: (c) B3
Explanation:
B3 also named as niacin.
Question 15.
With reference to enzymes, which one of the following statements is true?
(a) Apoenzyme = Holoenzyme + Coenzyme
(b) Holoenzyme = Apoenzyme + Coenzyme
(c) Coenzyme = Apoenzyme + Holoenzyme
(d) Holoenzyme = Coenzyme – Apoenzyme
Answer
Answer: (b) Holoenzyme = Apoenzyme + Coenzyme
Question 16.
Inhibitor binds to the active site of the enzyme. Hence blocking the reaction. This is an example of
(a) allosteric inhibition
(b) feedback inhibition
(c) uncompetitive inhibition
(d) competitive inhibition
Answer
Answer: (d) competitive inhibition
Explanation:
When substrate binds to the active site of the enzyme, it completes the reaction.
When inhibitor binds to the active site of the enzyme, it blocks the reaction.
Question 17.
The fastest enzyme known is
(a) DNA polymerase
(b) carbonic anhydrase
(c) carbonic dehydrogenase
(d) DNA ligase
Answer
Answer: (b) carbonic anhydrase
Explanation:
The fastest enzyme known is carbonic anhydrase. It converts 10^6 molecules of carbon dioxide molecules per second.

Question 18.
Lecithin is a
(a) polysaccharide
(b) protein
(c) nucleic acid
(d) lipid
Answer
Answer: (d) lipid
Explanation:
Lecithin is a phospholipid.
Question 19.
The minimum amount of energy required to initiate a chemical reaction is called
(a) enzymatic energy
(b) activation energy
(c) substrate energy
(d) initiation energy
Answer
Answer: (b) activation energy
Explanation:
The minimum amount of energy required to initiate a chemical reaction is called activation energy.
Question 20.
Enzymes, vitamins and hormones are common in
(a) Enhancing oxidative metabolism
(b) Being synthesised in the body of organisms
(c) Being proteinaceous
(d) Regulating metabolism
Answer
Answer: (d) Regulating metabolism

Solutions for Class 11 Biology Chapter 9 Biomolecules:

Section Name	Topic Name
9	Biomolecules
9.1	How to Analyse Chemical Composition?

9.2	Primary and Secondary Metabolites
9.3	Biomacromolecules
9.4	Proteins
9.5	Polysaccharides
9.6	Nucleic Acids
9.7	Structure of Proteins
9.8	Nature of Bond Linking Monomers in a Polymer
9.9	Dynamic State of Body Constituents – Concept of Metabolism
9.10	Metabolic Basis for Living
9.11	The Living State
9.12	Enzymes
9.13	Summary

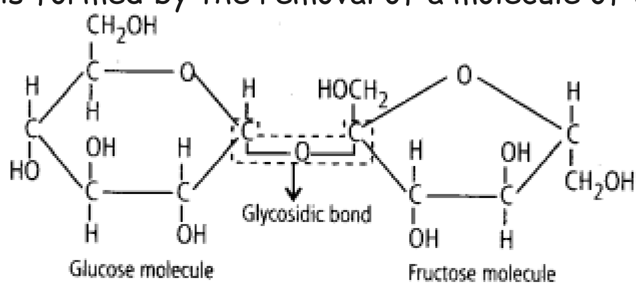
TEXTBOOK QUESTIONS SOLVED

1. What are macromolecules? Give examples.

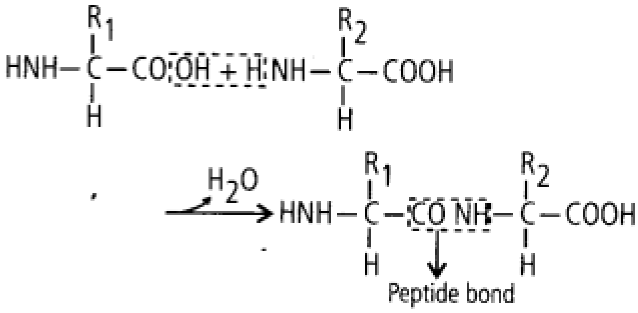
Solution: Macromolecules are large high molecular weight substances with complex molecular structure and occur in colloidal state (being insoluble) in intracellular fluid. These are formed by polymerization of large number of micromolecules. Polysaccharides, proteins and nucleic acids are few examples.

2. Illustrate a glycosidic, peptide, and a phospho- diester bond.

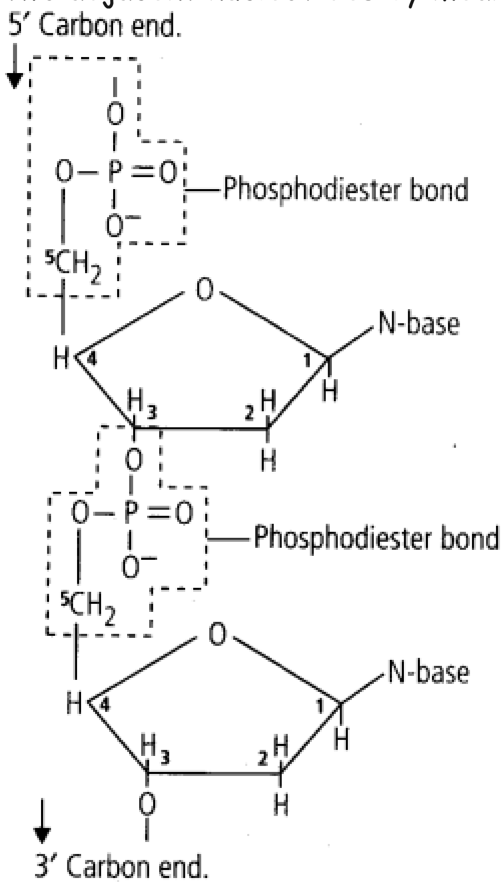
Solution. (i) Glycosidic bond is the type of chemical linkage between the monosaccharide units of disaccharides, oligosaccharides and polysaccharides, which is formed by the removal of a molecule of water.



(ii)Peptide bonds are formed by the reaction between carboxyl (- COOH) of one amino acid and amino (- NH2) group of other amino acid with the elimination of water.



(iii) In a polynucleotide chain, adjacent nucleotides are joined together by a bond called phosphodiester bond. This bond links a phosphate group and sugar group of two adjacent nucleotides by means of an oxygen bridge.



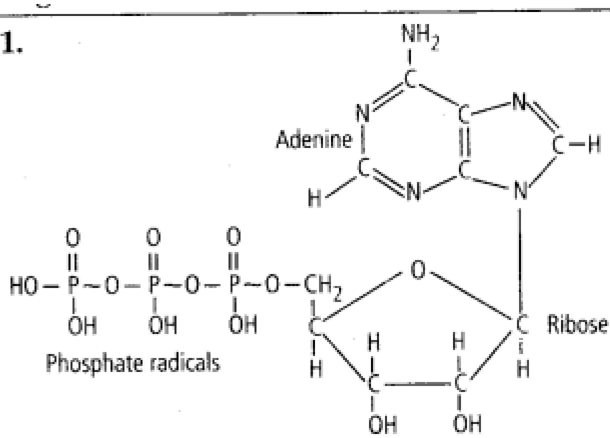
3. What is meant by tertiary structure of proteins?

Solution: The helical polypeptide molecule may fold on itself and assume a complex but specific form-spherical, rod-like or any form in between these. These geometrical shapes,are known as tertiary (3°) structure of protein molecules. The coils and folds of the polypeptide molecules are so arranged as to hide the non-polar amino acid chains inside and to expose the polar side chains. The tertiary structure of a protein brings distant amino acid side chains nearer to form active sites of enzymatic proteins. The tertiary structure is maintained by weak bonds such as hydrogen, ionic, disulphide and hydrophilic – hydrophobic bonds, formed between one part of a polypeptide and another. This structure is easily disrupted by pH, temperature and chemicals stopping the function of proteins.

4. Find and write down structures ©f 10 interesting small molecular weight biomolecules.

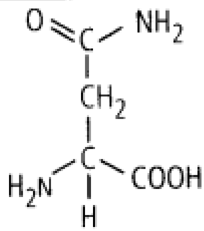
Solution: Interesfing small molecular weight biomolecules are minerals (like sodium, potassium, calcium, zinc, iodine etc), gases (like Oz, N2, C02, NH3) sugars – (ribose, deoxyribose, glucose, fructose), lipids, amino acids, nucleotides (pyrimidines & purine). Structures of 10 interesting small molecular weight biomolecules are as follows:

1.



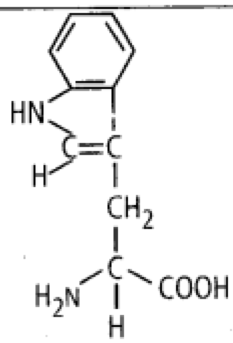
ATP molecule

2.



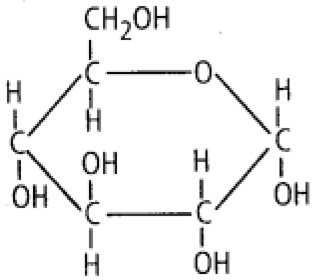
Asparagine (Asn)

3.



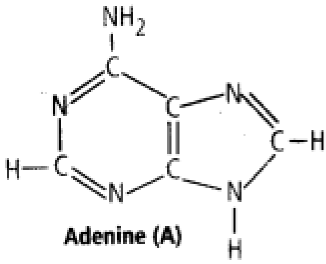
Tryptophan (Trp)

4.



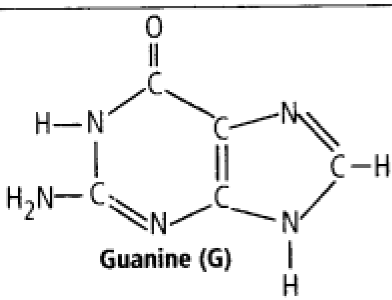
Glucose

5.



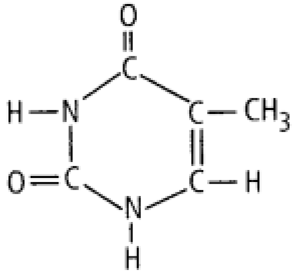
Adenine (A)

6.



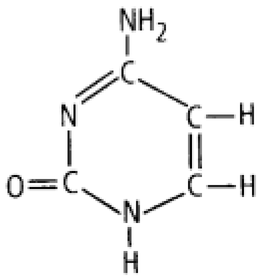
Guanine (G)

7.



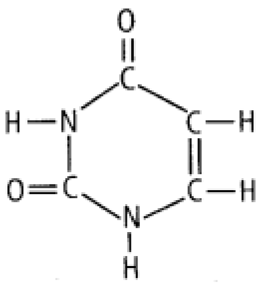
Thymine (T)

8.



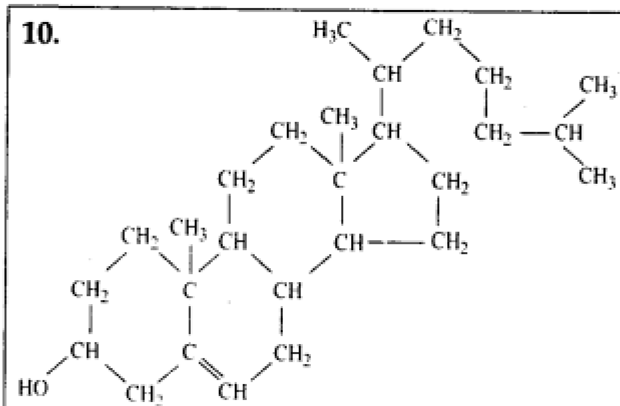
Cytosine (C)

9.



Uracil (U)

10.



Cholesterol

5. Proteins have primary structure. If you are given a method to know which amino acid is at either of two termini (ends) of a protein, can you connect this

information to purity or homogeneity of a protein?

Solution: There are several methods provided by several scientists to find out the sequence of amino acids. Frederick Sanger proposed Sanger's reagent to know the amino acid sequence in a polypeptide chain.

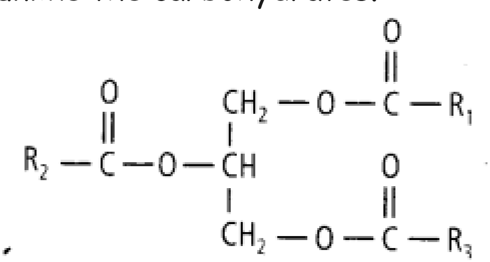
Sanger used 1-fluoro 2, 4 dinitrobenzene (FD NB) to determine insulin structure. FDNB specifically binds with N-terminal amino acid to form a dinitrophenyl (DNP) derivative of peptide. This DNP- derivative peptide can be identified by chromatography. The identified sequence of amino acids shows the homogeneity of a protein molecule.

6. Find out and make a list of proteins used as therapeutic agents. Find other applications of proteins.

Solution: Proteins used as therapeutic agents are: thrombin, fibrinogen, enkephalins, antigens, antibodies, streptokinase, protein tyrosine kinase, diastase, renin, insulin, oxytocin, vasopressin etc. Proteins are also used in cosmetics, dairy industries, textile industries, research techniques, biological buffers etc.

7. Explain the composition of triglycerides. jSfflTriacylglycerols (triglycerides) are the esters of glycerol with fatty acids.

Solution: They are insoluble in water and non-polar in character and commonly known as neutral fats. The neutral or depot fats are composed of carbon, hydrogen and oxygen like carbohydrates but have far fewer oxygen atoms than carbon atoms unlike the carbohydrates.



Triglyceride (R_1, R_2 and R_3 are fatty acids)

(i) Glycerol – A glycerol molecule has 3
carbons, each bearing a hydroxyl (-OH) group. .

(ii) Fatty acids – A fatty acid molecule is an unbranched chain of carbon atoms with each carbon atom (C) forming four bonds to other atoms. It has a carboxyl group-COOH at one end and hydrogen atom (H) bonded to all or most carbon atoms forming a hydrogen chain. The carbon- hydrogen bonds are non-polar. Therefore, the hydrocarbon chain does not dissolve in water. Because the carboxyl group contains the polar C = O and OFI groups. It tends to dissolve in water even though the rest of fatty acid molecule will not. Triacylglycerols of plants, in general, have higher content of unsaturated fatty acids as compared to that of animals.

8. Can you describe what happens when milk is converted into curd or yoghurt, from your understanding of proteins.

Solution: Milk is converted into curd or yoghurt due to denaturation of proteins. In denaturation, disruption of bonds that maintains secondary and tertiary structure leads to the conversion of globular proteins into fibrous proteins. This involves a change in physical, chemical and biological properties of protein molecules.

9. Can you attempt building models of biomolecules using commercially available atomic models (Ball and stick models).

Solution: Yes, models of biomolecules can be prepared using commercially available atomic models.

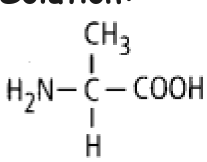
Ball and stick models and space filling models are 3D or spatial molecular models which serve to display the structure of chemical products and substances or biomolecules. With ball and stick models, the centers of the atoms are connected by straight lines which represent the covalent bonds. Double and triple bonds are often represented by springs which form curved connections between the balls. The bond angles and bond lengths reflect the actual relationships, while the space occupied by the atoms is either not represented at all or only denoted essentially by the relative sizes of the spheres.

10. Attempt titrating an amino acid against a weak base and discover the number of dissociating (ionizable) functional groups in the amino acid.

Solution: The existence of different ionic forms of amino acids can be easily understood by the titration curves. The number of dissociating functional group is one in case of neutral and basic amino acids and two in case of acidic amino acids.

11. Draw the structure of the amino acid, alanine.

Solution:



Alanine

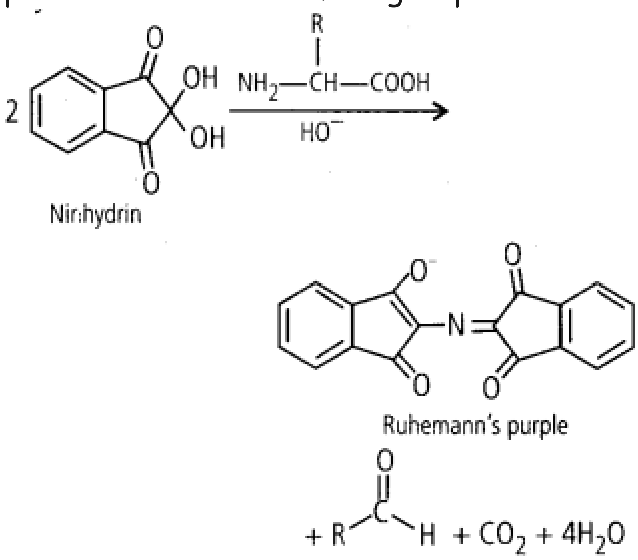
12. What are gums made of ? Is fevicol different ?

Solution: Gums are hetero-polysaccharides (poly-mers) of large number of different monosac-charide units. Yes, fevicol is a different kind of polymer. It is a synthetic sticky substance called resin which is manufactured by esteri-fication of organic compounds.

13. Find out a qualitative test for proteins, fats and oils, amino acids and test, any fruit juice, saliva, and urine for them.

Solution: Biuret test for protein : The biuret test is a chemical test used for determining the presence of peptide bonds. In a positive test, a copper II ion (Cu2+ ion) is reduced to copper I (Cu+) which forms a complex with the nitrogen and carbon of peptide bonds in an alkaline solution. A violet colour indicates the presence of proteins.

Ninhydrin test for amino acid: Ninhydrin (2,2 Dihydroxy indane-l,3-dione) is a chemical used to detect ammonia or primary and secondary amines. When reacting with these free amines, a deep blue or purple colour known as Ruhemann's purple is evolved. Amino acid analysis of proteins is also done by ninhydrine. Most of the amino acids (including a-amino acids) are hydrolysed and reacted with ninhydrin except proline (a secondary amine). Amino acid containing a free amino group and a free carboxylic acid group reacts together with ninhydrin to produce coloured product. When the amino group is secondary, the condensation product is yellow.



Solubility test for fats and oils : A positive solubility test for fats is that the fat dissolves in lighter fluid and not in water. In this test, 5 drops of fat or oil are added in two test tubes containing 10 drops of lighter fluid and 10 drops cold water respectively.

Fruit juice contains sugar so it cannot be tested by the above-mentioned tests.

Saliva contains proteins, mineral salts, amylase etc., so it can be tested for protein and amino acids. Urine contains proteins, so it can be tested for it.

14. Find out how much cellulose is made by all the plants in the biosphere.
Solution: About 100 billion tonnes of cellulose is prepared per year by the plants of the world.

15. Describe the important properties of enzymes.
Solution: The important properties of enzymes are as follows:
(i) The enzymes are generally proteins which are high molecular weight complex globular proteins. They can associate with non-protein substance for their activity.
(ii) The enzymes do not start a chemical reaction but only accelerate it. They combine temporarily with the substrate molecules and are not consumed or changed permanently in the reaction which they catalyse.
(iii) The enzyme controlled reactions are reversible.
(iv) The enzymes are specific in action. An enzyme catalyses only a particular kind of reaction or acts on a particular substrate only.
(v) The enzymes are thermolabile i.e., heat sensitive and can function best at an optimum temperature. Similarly, enzymes show maximum activity at optimum pH.
(vi) The enzymes are inactivated by poisons and radiation.

Cell Cycle and Cell Division Class 5 Notes Biology Chapter 10

Each and every organism begins its life from single cell and grows to form large organism. All living cells grow in size and reproduce by dividing into two daughter cells, i.e., each parental cell divide and give rise to two daughter cells each time it divide, which again grow, divide and give rise to new cell population.
Therefore, such cycles of growth and division allows a single cell to form a structure that consists of millions of cells. Hence, the development of a multicellular organism from the unicellular zygote is achieved by the process of cell division.

Topic 1 Cell Cycle and Mitosis

Cell Cycle
Cell division is an essential process in all living organisms. The mode of cell division is fundamentally similar in all organisms. During the process of division of a cell, the processes like DNA replication and cell growth must take place in a sequential and coordinated manner to ensure the correct division and formation of progeny cells with intact genomes.

Cell cycle is an orderly sequence of events or a set of stages by which a cell duplicates its genome, synthesises the other constituents (important for the cell) of the cell and eventually divides into two daughter cells.

In terms of cytoplasmic increase, cell growth is a continuous process, while DNA synthesis occurs during a specific stage of the cell cycle only. The DNA (chromosomes) are further distributed to daughter nuclei by a series of events. All these events are well coordinated and are under __ genetic control.

Phases of Cell Cycle

A typical eukaryotic cell (human cell) divides once in every 24 hr. This duration of cell cycle can vary from an organism to organism and also from one cell type to another, e.g., Yeast cell progress through the cell cycle in only about 90 min.

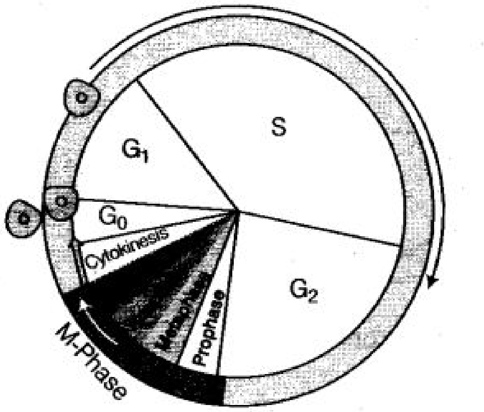


Fig.10.1 Diagrammatic view of a cell cycle indicating formation of two cells

The cell cycle is divided into two phases

i. Interphase

It is the period between the end of one cell division to the beginning of the next cell division, i.e., (between two successive M-phase). As no visible changes are observed at this stage, interphase is said to be Besting stage.

Daring this phase, cell prepares itself for both cell growth and DNA replication in an orderly manner. So, it is also known as preparation phase. It lasts for about 90-§6%, i.e., more than 95% of the total duration of cell cycle.

Interphase is further divided into fallowing three sub-stages on the basis of various synthetic activities

a. G_1(Gap-l)-phase

It corresponds to the duration between the mitosis (M-phase) and initiation of replication of DNA. The cell become metabolically active during this period, grows continuously and prepares itself for DNA replication but does not undergo DNA replication.

b. S (Synthesis)-phase

It is known to be the phase in which actual synthesis or replication of DNA takes place. The overall amount of DNA doubles per cell, but no increase in chromosome number is seen during this stage, e.g., If the initial amount of DNA is 2C it will become 4C.

In case of animal cell, during S-phase DNA replication begins inside the nucleus while, the duplication of centrioles takes place in the cytoplasm.

c. G_2(Gap-2)-phase

This phase is also called post-synthetic or pre-mitotic phase. During this stage the synthesis of DNA stops and proteins required for mitosis are being synthesised while, the growth of cell continues. It prepares the cell to undergo division.

Repair of damaged DNA and duplication of mitochondria, centrioles and plastids takes place during this phase.

G_0-phase (Quiescent Stage)

This is known as the stage of inactivation of cell cycle. Cells in G_0-phase remains metabolically active but do not proliferate, i.e., do not grow or differentiate till the time they do not get instruction to do so depending upon the requirement of an organism.

In adult animals, some cells like heart cells or nerve cells do not undergo division and many other cells divide only occasionally, to replace cells that have already _ been lost (because of some injury or cell death).

After completing G_2-phase a cell may enter either into the G_0-phase or into the M-phase directly. The duration of G_0-phase may vary from indefinitely long to very short, except the nerve, bone and heart cells of chordates that are in permanent G_0-phase.

a. M-phase

Following the interphase, the cell enters the M-phase or mitotic phase.

The M-phase may include any of the type of cell division i.e., mitosis or equational division and meiosis or reductional division. However, in general M-phase refers to mitotic phase.

M-phase also orderly involves the distribution of cell organelles and various macrobiomolecules to the daughter cells.

Mitosis

In this type of division the chromosomes replicate themselves and gets equally distributed into daughter nuclei, i.e., the chromosome number in the parental and progeny cell (diploid) become the same. Therefore, it is also known as equational division. Mitosis is also known as somatic cell division because it results in the formation of somatic cells.

Mitotic cell division is seen in the diploid somatic cells in animals, whereas, in plants; mitotic divisions is seen in both haploid and diploid cells.

Mitosis is considered to be the short period of chromosome condensation, segregation (karyokinesis) and cytoplasmic division.

It is known to be the phase of actual cell division, which starts with the division of nucleus, followed by the separation of daughter chromosomes, i.e„ karyokinesis and terminates with the cytoplasmic division,

i. e., cytokinesis.

Karyokinesis

It is further divided into four main sub-stages, i.e., prophase, metaphase, anaphase and telophase.

i. Prophase

It is known to be the longest and the most complex phase of cell division because it lasts for about 50 min of total duration of mitotic phase.

This is the first stage of mitosis that follows by the S and G_2-phase of interphase.

This phase is known for the initiation of condensation of chromosomal material, which during the process of chromatin condensation becomes untangled, and finally the centriole (already duplicated during S-phase of interphase) begins to move towards the opposite poles of the cell.

For the suitability in study we can categoriesprophase as

a. Early Prophase

During this phase, condensation of chromosomal material takes place in order to form a compact mitotic chromosomes composed of two chromatids which are attached together at centromere.

The most conspicuous change that take place during prophase is the formation of mitotic spindle. The initiation of mitotic spindle assembly, the micro¬tubules and

the proteinaceous components of the cell cytoplasm helps in the completion of the process.
The mitotic spindle is formed between the two pairs of centrioles that migrate towards the opposite poles of the cell.

b. Late Prophase
At the end of the prophase, i.e., during late prophase the nucleolus disintegrates gradually and the nuclear envelope disappear. This disappearance marks the end of the prophase.

If we view cells under the microscope, during the prophase the cell will not show nucleolus, nuclear envelope, Golgi complex, endoplasmic reticulum, etc.

ii. Metaphase
It is the phase that starts after the disintegration of nuclear envelope in the late prophase. The chromosomes spreadout through the cytoplasm of the cell and are seem to be slighdy shortest and thickest of all. The chromosome can be easily observed under the microscope.

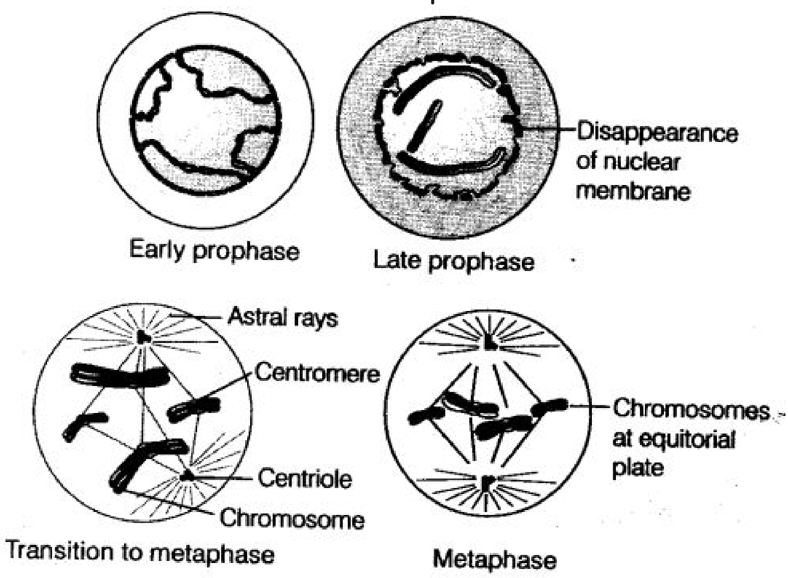


Fig. 10.2 A diagrammatic view of stages in mitosis

Mitotic Poison: Colchicine

Colchicine, an alkaloid is extracted from the corms of autumn crocus (Colchicum autumnale), acts as a poison for mitosis as it does not allow the formation of mitotic spindle to take place by preventing the assembly of microtubules. But does hot affect replication of chromosomes. Thus, meristematic cells treated with this chemical show doubling of chromosomes. It usually causes arrest at metaphase of mitosis.

Each chromosome at this stage is made up of two longitudinal threads (sister chromatids) and are held together by the centromere in the centre. At the surface of each centromere disc-shaped structures called kinetochores are present, which helps in the attachment of spindle fibres to the chromosomes.

The chromosomes finally arrange themselves at the equator in one equitorial plane known as metaphase plate.

Following changes are observed during metaphase
(a) Attachment of spindle fibres to kinetochores of chromosomes.
(b) Movement of chromosomes to spindle equator and its
alignment along the metaphase plate through spindle fibres to both poles.

Note:
Kinetochore are the small disc-shaped structures at the surface of the centromeres, which serve as the sites of attachment of spindle fibres to the chromosomes that are moved into position at the centre of the cell.
Chromosomes are attached to the polar fibres at the kirtetochores, through kinetochore fibres.

iii. Anaphase
It is known to be the shortest duration phase, i.e., only of 2-3 min and is also very simple stage. At the beginning of this phase, splitting of chromosomes (that are already arranged at metaphase plate) takes place.
The two daughter chromatids now becomes the chromosomes of future daughter nuclei and start migrating towards the opposite poles along the path of their chromosome fibres.
Thus, following changes are observed during anaphase
(a) Splitting of centromeres and separation of chromatids.
(b) Movement of chromatids towards the opposite poles.

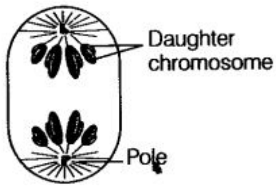


Fig. 10.3 Diagrammatic view of a stage in mitosis (anaphase)

iv. Telophase

This is considered to be long and complex phase like prophase the final stage of mitosis. At the onset of this stage, the spindle disappears (absorbed in cytoplasm) and the chromosomes decondense and further loses their individuality after reaching their respective poles. In general terms, the events of prophase occurs just in reverse sequence during this phase.

Now the, individual chromosomes can not be seen and the chromatin material gets collected in the form of mass in both opposite poles.

Thus, following changes are observed during telophase

(a) The chromosomes gradually uncoil and cluster at opposite spindle poles. Thus, their individual identity as discrete elements is lost.

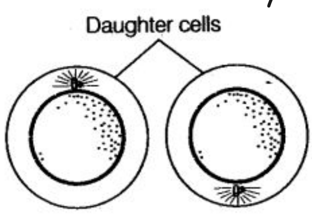


Fig. 10.5 A diagrammatic view of stage in mitosis (interphase)

(b) Nuclear envelope slowly reformed around group of chromosomes.
(c) Reappearance of nucleolus, Golgi complex and ER also takes place.

Cytokinesis

It is commonly known as the division of cytoplasm of the parent cell into two daughter cells after the division of nucleus or karyokinesis. It occurs, so that the each daughter cell can receive nucleus of its own.

Thus, mitosis is not only the segregation of nucleus into two daughter nuclei, infact, the cell also divide itself into two daughter cells.

Differences between Karyokinesis and Cytokinesis

Karyokinesis	Cytokinesis
It is known as division of daughter chromosomes M-phase.	It is known as division of cytoplasm.
Occurs or starts with karyokinesis itself.	Occurs at the end of M-phase.
It can occur independent of cytokinesis.	It cannot occur without karyokinesis.

Cytokinesis in Animal Cells

In animal cells, cytokinesis starts at metaphase. They typically divide by furrowing or by the appearance of furrow in the plasma membrane. This is also known as cleavage.
Due to the contraction and development of micro- filaments, a constriction develops which further deepens in a centripetal way known as cell furrow.
The furrow starts deepening gradually during telophase and finally gets joined in the centre by dividing the cytoplasm into two.

Cytokinesis in Plant Cells

Cytokinesis in plant cells is different from that in the animal cells due to the presence of a solid, rigid and in- extensible cell wall on the outside of the cell, the plant cell cannot undergo cytokinesis by the furrowing method. Therefore, plant cell divides by the cell-plate method. The formation of cell-plate usually begins during the late anaphase or early telophase. The formation of a new wall in plant cells takes place in the centre of the cell and start growing outward towards the opposite sides in order to reach the already existed lateral walls.
This new cell wall with the formation of simple precursor grows until it reaches the actual cell walls.

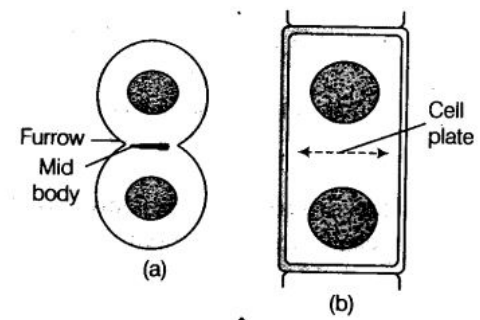


Fig. 10.6 Cytokinesis : (a) Furrowing in animal cells (b) Cell-plate formation in plant cells

Once cell plate has divided the cell into two cells, it will continue to grow and develop into a new cell organelles (like mitochondria and plastids) and also gets distributed among two daughter cells during the cytoplasmic division or cytokinesis.

Significance of Mitosis

Mitosis has following significance

(i) It helps in the production of diploid daughter cells with equal and identical genetic complement.

(ii) Mitosis helps in growth of multicellular organisms.

(iii) It also helps in maintaining a proper cell size by dividing an overgrown somatic cell.

(iv) It is helpful in cell repair mechanism, eg., continuous replacement of the cells like of the upper layer of the epidermis, cells of the lining of the gut, and blood cells.

(v) The growth of multicellular organism is due to mitosis as, it is known that a cell cannot grow in size beyond a certain limit without disturbing the ratio between the nucleus and the cytoplasm.

After reaching the particular size, the cell divides in order to restore the nucleocytoplasmic ratio. Therefore, the growth of cell takes place by the increase in the number of cells, rather than the increase in the size of the cell.

(vi) It is also helpful in producing new cells for healing wounds and for regeneration.

(vii) Mitosis plays an important role in continuous growth of plants throughout their life by meristematic tissues like the apical and the lateral cambium.

Differences between Mitosis in Animal and Plant Cells

Animal Cells	Plant Cells
Centrioles present at spindle poles.	Centrioles are absent at spindle poles.
Cytokinesis by furrowing of cytoplasm.	Cytokinesis mostly by cell plate formation.
Microfilament ring brings about cleavage.	Microfilaments have no role in cytokinesis.
Occurs nearly in all tissues.	Occurs mainly at meristems.
Cell does not change their forms or nature at the time of mitosis.	Cell becomes rounded and its cytoplasm become more viscous during mitosis.
Intercellular spaces appear between the daughter lamella.	Daughter cells remain adhered together by middle lamella.
Animal mitosis is controlled by certain mitogens.	Plant mitosis is usually controlled by a hormone cytokinin.
Midbody is formed at the equator of the spindle.	Equator of the spindle changes into phragmoplast.
Furrow extends centripetally.	Cell plate grows centrifugally.
Asters are formed (amphiastral).	No asters are formed (anastral).

Topic 2 Meiosis

Meiosis is the phenomenon which occurs in any life cycle that involves the process of sexual reproduction. The production of offspring by sexual reproduction involves the fusion of two gametes (each having a complete haploid set of chromosomes).

Thus, meiosis is known to be the specialised form of cell division which reduces the chromosome number in such a way that each daughter nuclei receive only one set of each kind of chromosome, {i.e., maternal and paternal). It results in the production of haploid daughter cells. In meiosis, the nucleus divides twice but the replication chromosome takes place only once.

Thus, it is also known as the reductional division. In case of diploid organisms, meiosis takes place during the formation of spores or gametes whereas, in haploid organisms it takes place during germination of zygote.

Meiosis ensures the production of haploid phase in the life cycle of sexually reproducing organism whereas, the fertilisation restores diploid phase.

During this division, the homologous chromosomes of each pair separates from each other and reaches separate daughter cells which thereby reduces the number of chromosomes from diploid to haploid, i.e., from 2n to n. Thus, it is known as heterotypic division. It is farther divided into four phases,
i. e., prophase-I, metaphase-I, anaphase-I and telophase-I.

Prophase-I
It is considered to be the most complicated and prolonged phase as compared to the similar stage in mitosis.
This phase is further sub-divided into five sub-phases on the basis of chromosomal behaviour, i.e., leptotene, zygotene, pachytene, diplotene and diakinesis.
i. Leptotene
It is known to be the very first stage of meiotic division following the interphase.

Following features are seen during this phase

- Chromosomes becomes gradually visible under light microscope.
- Centrioles start moving towards opposite ends or poles and ' each centriole develops astral rays.
- Each chromosome is attached to the nuclear envelope through the attachment plate at both of its ends.

The essential features of meiosis are as follows
(a) Meiosis undergoes two successive cycles of nuclear and cytoplasm division, i.e., meiosis-I and II, but no DNA replication will result prior to second meiotic division.
(b) Meiosis-I and II occurs one after the another with a very short or no interphase.
(c) After the replication of parental chromosomes, initiation of meiosis-I takes place in order to produce identical sister chromatids at S-phase.
(d) Meiosis takes about days to gets completed instead of hours or minutes that are needed for mitosis.
(e) Pairing of homologous chromosomes and recombination takes place during meiosis.
(f) Finally, after the second meiotic division four haploid cells are being formed.

Homologous Chromosomes

There are two sets of chromosomes in a diploid cell undergoing meiosis, one set contributed by the male parent and the other by the female parent. There are always two similar chromosomes, having the same size, shape and position of centromere. In some organisms, the chromosomes give beaded appearance due to the presence of chromomeres (swollen area).

ii. Zygotene

This is the next sub-stage that takes place after the completion of the previous one. This is also a short lived stage like leptotene.

Following changes are seen during this phase

Homologous chromosomes pair up. This pairing is done in a such a way that the genes of the same character present on the two chromosomes lie exactly opposite to each other. This process of association is known as synapsis.

It is revealed from the electron micrographic studies that the formation of synaptonemal complex takes place by a pair of homologous chromosomes that show synapsis. The complex so formed, on account of synapsis forms a bivalent or a tetrad.

The number of bivalents are half the total number of chromosomes and are not clearly visible at this stage.

iii. Pachytene

This is the stage which immediately follows zygotene where the pair of chromosomes become twisted spirally around each other and cannot be distinguished separately. This stage is comparatively long lived as compared to the previous two stages.

Following changes are seen during this stage

Bivalent chromosomes clearly seen as tetrads.

In this stage, sometimes exchange of genes or crossing over between the two non-sister chromatids of homologous chromosomes occurs at the points called recombination nodules, which appear at intervals, on synaptonemal complex. By the end of pachytene recombination gets completed leaving the chromosomes linked at the sites of crossing over.

Crossing Over

In this process, exchange of genetic material takes place between the non-sister chromatids of two homologous chromosomes. It finally leads to recombination of genetic material on the two chromosomes.

iv. Diplotene

It is the stage of longest duration of all. Following changes are observed during this stage

- In this the synaptonemal complex appears to get dissolved while, the chromatids of each tetrad remain clearly visible.
- Recombined homologous chromosomes of the bivalents get separated and form chiasmata (X-shaped structures).
- Chiasmata formation is necessary for the separation of homologous, chromosome which have undergone the process of crossing-over.
- Diplotene can last for months or years in oocytes of some vertebrates.

v. Diakinesis

This is known to be the final stage of meiotic prophase-I. Also known as terminalisation, due to the shifting of chiasmata towards the end of the chromosomes. Following changes are observed during this stage

- Chromosomes become fully condensed.
- Nucleolus degenerates.
- Breakdown of nuclear envelope into vesicles.
- Formation of meiotic spindle (as in mitosis) in order to prepare the homologous chromosomes for separation.

- Diakinesis is the phase which represents the transition from prophase to metaphase of meiosis-I.

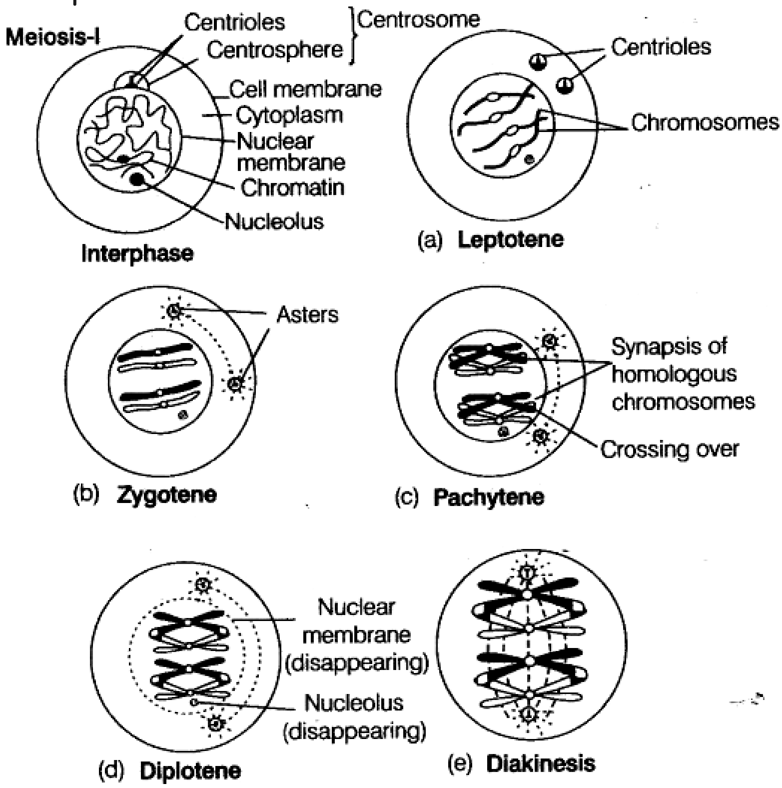


Fig. 10.7 Different stages of prophase-I (meiosis-I) in an animal cell

Metaphase-I

It is the stage followed by prophase (same as mitosis). Following changes are observed during this stage

(a) The bivalents during this phase arrange themselves on the two parallel equatorial plates.

(b) The centromeres project litde bit towards periphery. Since, there are two centromeres in each bivalent. Thus, each centromere is joined by chromosomal fibres.

(c) The fibres of the homologous chromosomes are always in the opposite directions.

Anaphase-I

This is the next phase after metaphase-I in which homologous chromosomes break their connection with each other and get separated.

This process of separation of homologous chromosomes is known as disjunction. The separated chromosomes are univalents and are also called dyads.

On reaching at the end of the anaphase, the two groups of chromosomes are produced (with each having half number of chromosomes).

The sister chromatids remains attached at their centromeres on the separation of the homologous chromosomes .

Telophase-I
This is the last stage of meiosis-I in which the chromatids at each pole of the spindle usually remain uncoiled and get elongated.

Following changes are seen during this stage
(i) Homologous chromosomes reach at their respective poles!
(ii) Reappearance of nuclear membrane and nucleolus takes place.

Cytokinesis
It is die stage during which the cytoplasm and other organelles divides into two equal halves of cells.
Interkinesis
This is the stage betweenJbe two meiotic divisions, i.e., the meiosis-I and II. It is generally short lived. During this process, no replication of DNA occurs. It is necessary for bringing true haploidy DNA in daughter cells.
It is in fact considered as incipient interphase.

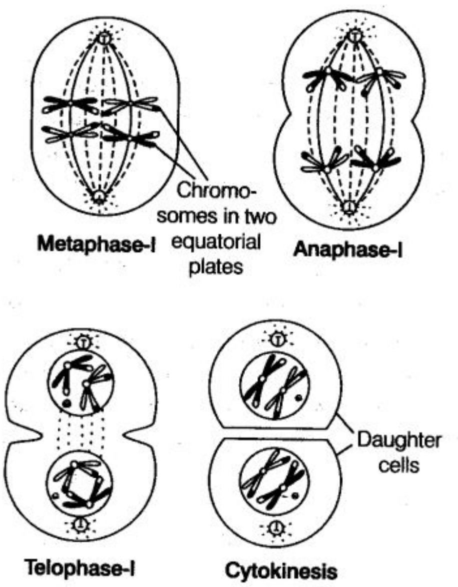


Fig. 10.8 Stages of meiosis-I

Meiosis-II

Meiosis-II is known by another term, i.e., homotypic division, because in this division chromosome number remains same, as produced in meiosis-I. It is initiated immediately after cytokinesis. It is often known an equational division. Meiosis-lf also resembles a normal mitotic division in contrast to meiosis-I because it distributes chromatids to daughter cells (like mitosis).

Prophase-ll

This is known to be the very short stage out of the all. During this process the chromosomes again become compact in organisation.

Following changes are seen during this process

(i) The centrioles duplicate themselves by the separation of the two members of the pair.

(ii) Each chromosome comprising two chromatids become visible in the nucleus. These chromosomes further become thick and short in size.

(iii) Nuclear envelope breaks down and the formation of spindle apparatus takes place and nucleoli disappears.

Metaphase-ll

This is the next phase followed immediately after prophase-II.

Follotving changes are seen during this process

(i) The chromosomes align at the equator or the metaphase plate, in the similar way

as in_mitosis.
(ii) Chromosomes get attached to the fully formed spindle apparatus and the kinetochores of sister chromatids for each chromosome face the opposite poles and each is attached to the kinetochore microtubule coming from the pole of that side.

Anaphase-II
This is the phase followed immediately after metaphase-II.
Following changes are seen during this process
(i) The centromere of each chromosome splits, that was holding the sister chromatids together.
(ii) The shortening of chromosomal microtubules take place, the two chromatids of each chromosome start moving away from each other and finally reaches the opposite poles of the spindle (now called chromosomes).

Telophase-II
This is known to be the last stage of second meiotic division and show changes equally opposite to that of the prophase-II. Meiosis ends up with the progress of this particular phase, i.e., telophase-II.

Following changes are seen during this process
(i) Formation of a nuclear envelope (from ER) around each set of chromosomes.
(ii) Nucleoli reappears due to the synthesis of ribosomal RNA (rRNA) and ribosomal DNA (rDNA).

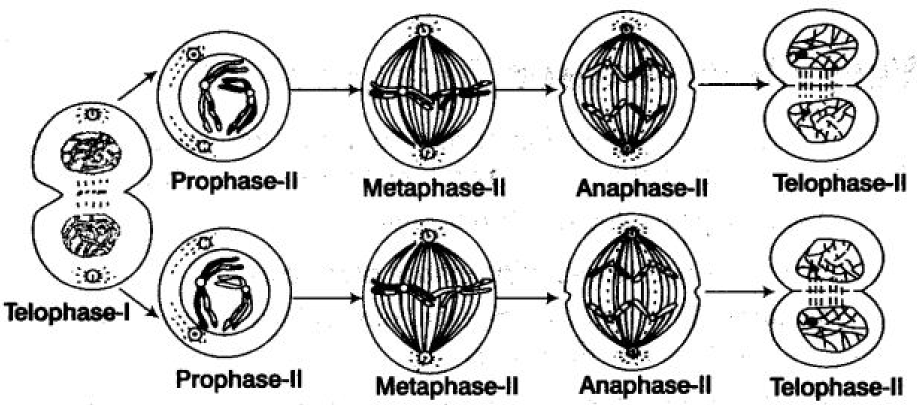


Fig. 10.9 Stages in meiosis-II (progressing from telophase-I of meiosis-I)

Cytokinesis

This occurs after every nuclear division. It includes separation of cytoplasm and organelles in the two halves of the cell. Thus, the two daughter cells formed have half the number of chromosomes and the amount of nuclear DNA. Both the cells undergo divisions and give rise to four cells. These haploid cells are arranged tetrahedrally and are collectively called tetrahedral tetrad.

It usually send equal amounts to each daughter cells but sometimes division is highly unequal (especially in egg production).

Note:
Cytokinesis may or may not occur between meiotic divisions, however, in most of the organisms it is of rare occurrence after Mitosis and Meiosis-ll.

Significance of Meiosis-ll
(i) It maintains the same chromosome number in the sexually reproducing organisms. From a diploid cell, haploid gametes are produced which in turn fuse to form a diploid cell. Haploid gametes are formed due to reduction of chromosomes to its half.
(ii) It restricts the multiplication of chromosome number and maintains the stability of the species.
(iii) Maternal and paternal genes get exchanged during crossing over. It results in variations among the offspring.

(iv) All the four chromatids of a homologous pair of chromosomes segregate and go over separately to four different daughter cells. This leads to variation in the daughter cells genetically.

(v) Paternal and maternal chromosomes assort independendy. Thus, cause reshuffling of chromosomes and traits controlled by them.

Differences between Mitosis and Meiosis

Mitosis	Meiosis
The division occurs in somatic cells.	It occurs in reproductive cells.
It is a single division.	It is a double division.
The daughter cells resemble each other as well as their mother cell..	The daughter cells neither resemble one another nor their mother cell.
Replication of chromosomes occurs before every mitotic division.	Replication of chromosomes occurs only once though meiosis is a double division.
Mitosis does not introduce variations.	Meiosis introduces variations.
Mitosis is required for growth, repair and healing.	Meiosis is involved in sexual reproduction.

Cell Cycle and Cell Division Class 5 MCQs Questions with Answers

Question 1.
Meiosis is evolutionary significant because it result in
(a) genetically similar daughters
(b) four daughter cells
(c) eggs and sperms
(d) recombinations
Answer
Answer: (d) recombinations
Question 2.
Synapsis occurs between
(a) A male and female gametes
(b) Ribosome and m-RNA
(c) Spindle fibres and centromeres
(d) Two homologous chromosomes
Answer
Answer: (d) Two homologous chromosomes
Question 3.
Division of nucleus without being followed by cytokinesis results into
(a) Phargmoplast
(b) Polyploidy
(c) Uninucleate condition
(d) Multinucleate condition
Answer
Answer: (d) Multinucleate condition

Question 4.
A cell plate is laid down during
(a) Cytokinesis
(b) Interphase
(c) Karyokinesis
(d) None of these
Answer
Answer: (a) Cytokinesis
Question 5.
Crossing over results the exchange of genetic material, which occurs between
(a) Non-sister chromosomes
(b) Sister chromatids
(c) Non-homologous chromosome
(d) Homologous chromosomes
Answer
Answer: (d) Homologous chromosomes
Question 6.
The number of chromosome and the amount of DNA are changed in
(a) Metaphase and M phase
(b) Anaphase and S phase
(c) Interphase and S phase
(d) None of these
Answer
Answer: (b) Anaphase and S phase
Question 7.
Which of the following statements is not true for cancer cells in relation to mutations?
(a) Mutations in proto-oncogenes accelerate the cell cycle.
(b) Mutations destroy telomerase inhibitor.
(c) Mutations inactive the cell control.
(d) Mutations inhibit production of telomerase.
Answer
Answer: (d) Mutations inhibit production of telomerase.
Question 8.
In cell cycle, DNA replication takes place in
(a) G1 phase
(b) G2 phase

(c) Mitotic metaphase
(d) S phase
Answer
Answer: (d) S phase
Question 9.
Which of the phases of mitosis is the longest?
(a) Telophase
(b) Prophase
(c) Anaphase
(d) Metaphase
Answer
Answer: (b) Prophase
Question 10.
Chromosome appeared beaded during
(a) Diplotene
(b) Leptotene
(c) Diakinesis
(d) Panchytene
Answer
Answer: (b) Leptotene
Question 11.
In meiosis crossing over is initiated at
(a) Pachytene
(b) Leptotene
(c) Zygotene
(d) Diplotene
Answer
Answer: (a) Pachytene
Question 12.
Which one is not a significance of meiosis division?
(a) Formation of spores and gametes
(b) New recombination of genes
(c) Number of chromosome remain same
(d) Number of chromosome reduced to half
Answer
Answer: (c) Number of chromosome remain same
Question 13.
A somatic cell that has just completed the S phase of its cell cycle, as compared to

gamete of the same species, has:
(a) same number of chromosomes but twice the amount of DNA

(b) twice the number of chromosomes and four times the amount of DNA

(c) four times the number of chromosomes and twice the amount of DNA
(d) twice the number of chromosomes and twice the amount of DNA
Answer
Answer: (b) twice the number of chromosomes and four times the amount of DNA
Question 14.
The mechanism of distributing centriole pairs to the daughter cells is called
(a) Equational division
(b) Haplontic division
(c) Astral division
(d) Reductional division
Answer
Answer: (c) Astral division
Question 15.
Spindle fibres attach on to
(a) Telomere of the chromosome
(b) Kinetochore of the chromosome
(c) Centromere of the chromosome
(d) Kinetosome of the chromosome
Answer
Answer: (b) Kinetochore of the chromosome
Question 16.
Best stage to observe shape, size and number of chromosomes is
(a) interphase
(b) metaphase
(c) prophase
(d) telophase
Answer
Answer: (b) metaphase
Question 17.
Plants show mitotic divisions in
(a) Haploid cells
(b) Haploid cells and diploid cells

(c) Somatic cells
(d) Diploid cells
Answer
Answer: (b) Haploid cells and diploid cells
Question 18.
Which of the following phases in mitosis is in correct order?
(a) Prophase, telophase, metaphase, anaphase
(b) Prophase ,metaphase, anaphase, telophase
(c) Anaphase, telophase, metaphase, prophase.
(d) Metaphase, prophase, anaphase, telophase
Answer
Answer: (b) Prophase ,metaphase, anaphase, telophase
Question 19.
In between two walls of adjacent cells are seen
(a) Cell wall
(b) Cytoplasm
(c) Middle lamellae
(d) Plasma membrane
Answer
Answer: (c) Middle lamellae
Question 20.
In the somatic cell cycle
(a) In G1 phase DNA content is double the amount of DNA present in the original cell
(b) DNA replication takes place in S phase
(c) A short interphase is followed by a long mitotic phase
(d) G2 phase follows mitotic phase
Answer
Answer: (b) DNA replication takes place in S phase
Question 21.
In 'S' phase of the cell cycle:
(a) Amount of DNA doubles in each cell.
(b) Amount of DNA remains same in each cell.
(c) Chromosome number is increased.
(d) Amount of DNA is reduced to half in each cell.
Answer
Answer: (a) Amount of DNA doubles in each cell.

Question 22.
In animal cells, the mitotic division is seen in
(a) Haploid somatic cells
(b) Diploid cells
(c) Diploid somatic cells
(d) Haploid cells
Answer
Answer: (c) Diploid somatic cells
Question 23.
Cell growth results in disturbing the ratio between
(a) Nucleus – chromosome ratio
(b) Cytoplasm-chromosome ratio
(c) Cytoplasm-spindle fibre ratio
(d) Nucleus-cytoplasm ratio
Answer
Answer: (d) Nucleus-cytoplasm ratio
Question 24.
Astral body are formed of
(a) Microtubules
(b) Intermediate filaments
(c) Microfilaments
(d) Microvilli
Answer
Answer: (a) Microtubules
Question 25.
The resting phase is otherwise called as
(a) Prophase
(b) Interphase
(c) Metaphase
(d) Telophase
Answer
Answer: (b) Interphase
Question 26.
In animal cells, Cytokinesis takes place by furrow deepening centripetally and formation of two daughter cells. This method is known as
(a) Phragmoplast
(b) Cleavage Cytokinesis

(c) Cell plate formation
(d) None of these
Answer
Answer: (b) Cleavage Cytokinesis
Question 27.
Multinucleate condition arise when Cytokinesis does not follow karyokinesis, this type of cells are called as
(a) Holotype
(b) Coenocyte
(c) Prototype
(d) Uninuleate
Answer
Answer: (b) Coenocyte
Question 28.
In which stage, the cells remain metabolically active but do not proliferate?
(a) G1-phase
(b) G2-phase
(c) Go-phase
(d) S-phase
Answer
Answer: (c) Go-phase
Question 29.
Cell division is initiated in plants by
(a) Cytokinin
(b) Abscisic acid
(c) Gibberellin
(d) Auxin
Answer
Answer: (a) Cytokinin
Question 30.
During mitosis ER and nucleolus begin to disappear at
(a) Early metaphase
(b) Late metaphase
(c) Late prophase
(d) Early prophase
Answer
Answer: (c) Late prophase

Solutions for Class 11 Biology Chapter 10 Cell Cycle and Cell Division:

Section Name	Topic Name
10	Cell Cycle and Cell Division
10.1	Cell Cycle
10.2	M Phase
10.3	Significance of Mitosis
10.4	Meiosis
10.5	Significance of Meiosis
10.6	Summary

TEXTBOOK QUESTIONS SOLVED

1. What is the average cell cycle span for a mammalian cell?

Solution: 24 hours.

2. Distinguish cytokinesis from karyokinesis.

Solution: Differences between cytokinesis and karyokinesis are:

	Cytokinesis	Karyokinesis
(i)	Cytokinesis is the division of the cytoplasm of a cell.	Karyokinesis is the division of the nucleus of a cell.
(ii)	It occurs at the end of M-phase, after the nuclear division is over.	It occurs during M-phase of cell cycle before the cytokinesis begins to proceed.

3. Describe the events taking place during the interphase.

Solution: The interphase, though called the resting phase, is metabolically quite active. It is the time during which the cell prepares itself for division by undergoing both cell growth and DNA replication in an orderly manner. The interphase is further divided into three phases:

• G1 (Gap 1) phase
• S (Synthesis) phase
• G2 (Gap 2) phase

G1 phase corresponds to the interval between mitosis of previous cell cycle and initiation of DNA replication. During G1 phase the cell is metabolically active and grows continuously but does not replicate its DNA S or synthesis phase marks the period during which DNA synthesis or replication takes place. During this time the amount of DNA doubles per cell. In animal cells, during the S phase, DNA replication occurs in the nucleus, and the centriole duplicates in the cytoplasm. During the G2 phase synthesis of DNA stops while cell growth continues with synthesis of protein and RNA in preparation for mitosis.

4. What is G0 (quiescent phase) of cell cycle?

Solution: G0 phase is the phase of inactivation of cell cycle due to non-availability of mitogens and energy rich compounds. Cells in this stage remain metabolically active but no longer proliferate i.e., do not grow or differentiate unless called on to do so depending on the requirement of the organism. E.g., Nerve and heart cells of chordates are in permanent G0 phase.

5. Why is mitosis called equational division?

Solution: Mitosis is a type of cell division in which chromosomes replicate and become equally distributed in two daughter nuclei so that the daughter cells come to have the same number and type of chromosomes as present in parent cell. So mitosis is called as equational division.

6. Name the stage of cell cycle at which each one of the following events occur:
(i) Chromosomes are moved to spindle equator.
(ii) Centromere splits and chromatids separate.
(iii) Pairing between homologous chromosomes takes place.
(iv) Crossing over between homologous chromosomes takes place.

Solution:
(i) Metaphase
(ii) Anaphase
(iii) Zygotene of prophase I of meiosis 1
(iv) Pachytene of prophase I of meiosis I

7. Describe the following:
(a) Synapsis
(b) Bivalent
(c) Chiasmata
Draw a diagram to illustrate your answer.

Solution:

(a) Synapsis: During zygotene of prophase I stage homologou s chromosomes start pairing together and this process of association is called synapsis. Electron micrographs of this stage indicate that chromosome synapsis is accompanied by the formation of complex structure called synaptonemal complex.
(b) Bivalent: The complex formed by a pair of synapsed homologous chromosomes is called a bivalent or a tetrad i.e., 4 chromatids or a pair of chromosomes.

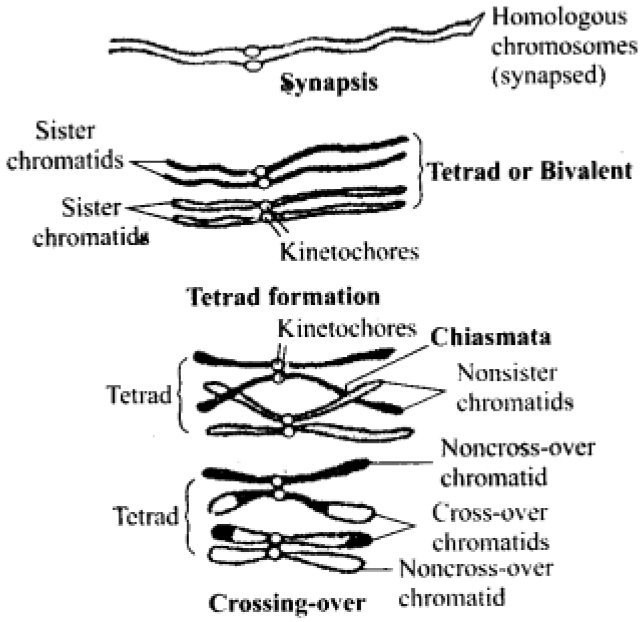


Fig.: Diagram showing synapsis, bivalent and chiasmata

(c) Chiasmata: The beginning of diplotene is recognized by the dissolution of the synaptonemal complex and the tendency of the synapsed homologous chromosomes of the bivalents to separate from each other except at the sites of crossovers. These points of attachment (X-shaped structures) between the homologous chromosomes are called chiasmata.

8. How does cytokinesis in plant cells differ from that in animal cells?

Solution: Plant cytokinesis and animal cytokinesis differ in following respects:

	Plant cytokinesis	Animal cytokinesis
(i)	It usually occurs by cell plate method.	It takes place by cleavage.
(ii)	The spindle usually persists during cytokinesis.	The spindle begins to degenerate soon after anaphase.
(iii)	Central part of spindle grows in size and forms an interdigited complex called phragmoplast.	A mid body of dense fibrous and vesicular material is formed in the middle.
(iv)	Vesicles derived from Golgi apparatus reach the equator of the phragmoplast and fuse to form cell plate and new cell membranes.	The event is absent in animal cytokinesis.
(v)	Cell plate grows centrifugally.	Cleavage progresses centripetally.
(vi)	The new cell membrane is derived from vesicles of Golgi apparatus.	The new cell membrane is usually derived from endoplasmic reticulum.

9. Find examples where the four daughter cells from meiosis are equal in size and where they are found unequal in size.

Solution: During formation of male gametes (i.e., spermatozoa) in a typical mammal (i.e., human being), the four daughter cells formed from meiosis are equal in size. On the other hand, during formation of female gamete (i.e., ovum) in a typical mammal (i.e., human being), the four daughter cells are unequal in size.

10. Can there be DNA replication without cell division?

Solution: Yes. Endomitosis is the multiplication of chromosomes present in a set in nucleus without karyokinesis and cytokinesis result-ing in numerous copies within each cell. It is of 2 types.

Polyteny: Here chromosomes divide and redivide without separation of chromatids so that such chromosomes become multistranded with many copies of DNA. Such polytene (many stranded) chromosomes remain in permanent prophase stage and do not undergo cell cycle e.g., polytene (salivary glands) chromosome of Drosophila has 512- 1024 chromatids. Here number of sets of chromosomes does not change.

Polyploidy (endoduplication) : Here all chromosomes in a set divide and its chromatids separate but nucleus does not divide. This results in an increase in number of sets of chromosomes in the nucleus (4x, 8x….). This increase in sets of chromosomes is called polyploidy. It can be induced by colchicine and granosan. These chromosomes are normal and undergo cell cycle.

11. List the main differences between mitosis and meiosis.

Solution:

	Mitosis	Meiosis
(i)	It occurs in all somatic cells and may continue throughout life.	It occurs in reproductive cells and at specific times.
(ii)	It involves a single division, resulting in two daughter cells only.	It involves two successive divisions, resulting in four daughter cells.
(iii)	Subsequent mitotic divisions are similar to the earlier ones.	Two meiotic divisions are dissimilar, first is reductional while the second is equational.
(iv)	Prophase is relatively short and simple.	Prophase I is very long and elaborate, comprising 5 subphases.
(v)	There is no pairing of homologous chromosomes.	Homologous chromosomes pair and often undergo crossing over in prophase I.
(vi)	Chromatids are genetically similar to chromosomes they arise from.	Chromatids may differ genetically from the chromosomes they arise from due to crossing over.
(vii)	No synaptonemal complex forms.	Synaptonemal complex forms between synapsed homologous chromosomes.
(viii)	Chromosomes do not unfold, and no transcription and protein synthesis occur in prophase.	Chromosomes unfold, and transcription and protein synthesis may occur in diplotene of prophase I (oocytes of certain animals).
(ix)	Daughter cells have diploid number (2N) of chromosomes like the parent cell.	Daughter cells have haploid number (N) of chromosomes unlike the parent cell.

12. Distinguish anaphase of mitosis from anaphase I of meiosis.

Solution: Anaphase of mitosis : It is the phase of shortest duration. APC (anaphase promoting complex) develops. It degenerates proteins -binding the two chromatids in the region of centromere. As a result, the centromere of each chromosome divides. This converts the two chromatids into daughter chromosomes each being attached to the spindle pole of its side by independent chromosomal fibre. The chromosomes move towards the spindle poles with the centromeres projecting towards the poles and the limbs trailing behind. There is corresponding shortening of chromosome fibres. The two pole-ward moving chromosomes of each type remain attached to each other by interzonal fibres. Ultimately, two groups of chromosomes come to lie at the spindle poles.

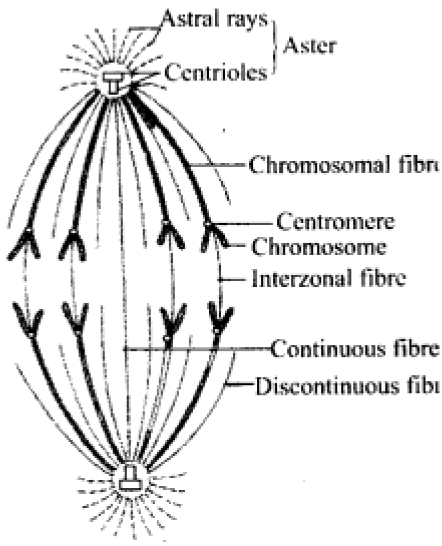


Fig.: Mitotic anaphase.

Anaphase I of meiosis : Chiasmata disappear completely and the homologous chromosomes separate. The process is called disjunction. The separated chromosomes (univalents) show divergent chromatids and are called dyads. They move towards the spindle poles and ultimately form two groups of haploid chromosomes.

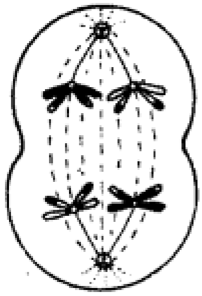


Fig.: Meiotic anaphase I

13. What is the significance of meiosis?

Solution: The significance of meiosis is given below:

(i) Formation of gametes – Meiosis forms gametes that are essential for sexual reproduction.

(ii) Genetic information – It switches on the genetic information for the development of gametes or gametophytes and switches off the sporophytic information. '

(iii) Maintenance of chromosome number – Meiosis maintains the fixed number of chromosomes in sexually reproducing organisms by halving the same. It is essential since the chromosome number becomes double after fertilisation.

(iv) Assortment of chromosomes – In meiosis paternal and maternal chromosomes assort independently. It causes reshuffling of chromosomes and the traits

controlled by them. The variations help the breeders in improving the races of useful plants and animals.
(v) Crossing over – It introduces new combination of traits or variations.
(vi) Mutations – Chromosomal and genomic mutations can take place by irregularities of meiotic divisions. Some of these mutations are useful to the organism and are perpetuated by natural selection.
(vii) Evidence of basic relationship of organisms – Details of meiosis are essentially similar in the majority of organisms showing their basic similarity and relationship.

14. Discuss with your teacher about
(i) haploid insects and lower plants where cell division occurs, and
(ii)some haploid cells in higher plants where cell division does not occur.
Solution:
(i) Cell division occurs in haploid insect, such as drones of honey bee and lower plant like gametophyte of algae, bryophytes, and pteridophytes.
(ii) Synergids and antipodals in embryo sac of ovule are haploid cells where cell division does not occur.

15. Can there be mitosis without DNA replication in S-phase?
Solution: No there cannot be any mitotic division without-DNA replication in 'S' phase.

16. Analyse the events during every stage of ceil cycle and notice how the following two parameters change.
(i) number of chromosomes (N) per cell
(ii) amount of DNA content (C) per cell
Solution: Number of chromosomes and amount of DNA change during S-phase and anaphase of cell cycle. S or synthesis phase marks the period during which DNA synthesis or replication takes place. During this time the amount of DNA per cell doubles. If the initial amount of DNA is denoted as 2C then it increases to 4C. However, there is no increase in the chromosome number; if the cell had diploid or 2N number of chromosomes at G„ even after S phase the number of chromosomes remains the same, i.e., 2N.
In mitotic anaphase, number of chromosomes remains the same. It is only sister chromatids which move towards their respective poles. DNA content remains unchanged. In anaphase I of meiosis, number of chromosomes are reduced to half, i.e., from 2N to IN and also DNA content decrease to one half i.e., from 4C to 2C.

In anaphase II of meiosis II DNA content decreases to one half from 2C to 1C but chromosome number remain same.

Transport in Plants Class 11 Notes Biology Chapter 11

In flowering plants, a complex movement of materials take place in different directions. This is despite the fact that plants do not bear any circulatory system. Water taken up by the roots has to reach all the parts of the plant, up to very tip of the growing stem, where photosynthesis and growth are going on. Leaves manufacture food, which has to be supplied to all parts of the plant including the roots.

Materials also move over short distances, i.e., inside the cell, across the membranes or even cell to cell. The substances transported are water, mineral, nutrients, organic nutrients and plant growth regulators. Over short distances the substances move by diffusion and cytoplasmic streaming supplemented by active transport while, the long distance transport takes place through xylem and phloem and is called translocation.

Topic 1 Transport and Plant Water Relations

In rooted plants, water and mineral transport in xylem is unidirectional (roots to stems). However, translocation of organic and inorganic nutrients is multi directional. Organic compounds synthesised in the leaves are transported to all parts including storage organs.
The storage organs later re-export these organic compounds when required. Important nutrients are also withdrawn from plant parts undergoing senescence and are supplied to the growing parts. Hormones and plant growth regulators are present in very minute quantities and are often transported in polarised (unidirectional) manner.

Means of Transport

Transport in plant is an important phenomenon. It can either be unidirectional or bidirectional. There are mainly three important methods of transport of materials into and out of cells, i.e., diffusion, facilitated diffusion and active transport. These process are given below in details

1. Diffusion

It is a physical process in which passive transport of solvent molecules or solute ions occur without the expenditure of energy. It is a slow process and is independent of living system. During the process, the molecules or ions flow in a random fashion from the region of higher concentration to region of lower concentration be it a gas, liquid or solids. Rate of diffusion is mainly affected by

(a) Concentration gradient of diffusing substance.

(b) Permeability of the membrane separating them.

(c) Temperature

(d) Pressure

(e) Density

Note:

- Diffusion rate is inversely related to square root of relative density of the diffusing substance. This is known as Graham's law of diffusion.

$$D \propto \frac{1}{\sqrt{d}}$$

where, D = diffusion

d = density

- Diffusion is a very important phenomenon in plants as it is the only means of transport of gases in them.
- Tendency of different substances to diffuse according to their own partial pressures or concentration is called independent diffusion.

2. Facilitated Diffusion

A favourable concentration gradient of molecules is essential for difiusion. The rate of difiusion depends on the size of the substances, i.e., smaller the substance, the faster it will diffuse and on its solubility in lipids (major constituents of membrane), i.e., more the substance is soluble in lipid, more faster it will diffuse through the membrane. Transport of substances (having hydrophilic moeity) is facilitated by transport proteins. These protein do not create any concentration gradient by themselves; a concentration gradient is already present.

This process is called facilitated difiusion. Facilitated diffusion does not allow net movement of molecules from low to high concentration because it will require input of energy. The rate of transport finally reaches the maximum when all transporters of proteins are utilised.

Facilitated diffusion is very specific, i.e., allows uptake of only selected substances.

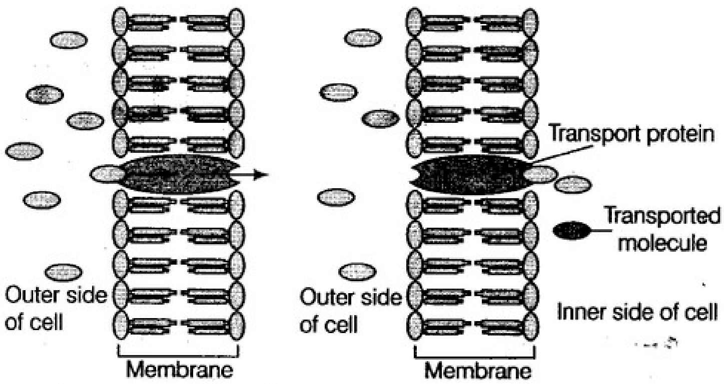


Fig. 11.1 Facilitated diffusion

There are two different types of transport proteins, i.e., carrier proteins and channel proteins. Carrier proteins bind the particular solute to be transported and deliver the same to the other side of the membrane.

The channel proteins form channels in the cell membrane so s that molecules can easily get transported. This is called channel mediated facilitated difiusion. Out of these channels, some always remain open while, the others are controlled. The large transporter proteins, which create huge pores in the outer membranes of the plastids, mitochondria and bacteria to cross a variety of molecules up to the size of small proteins are called porins.

During transportation, the extracellular molecule binds to the transport protein which then rotates towards the intracellular matrix and releases the molecule inside the cell, e.g., Water channels made up of eight different types of aquaporins.

Note:

Aquaporin are membrane proteins for passive transport of water. They enhance the rate of transport of water across the membrane without altering the direction of transport.

Passive Symports and Antiports

In relation to facilitated diffusion, some carrier or transport proteins allow the movement of molecules only if two molecules move together. This type of movement is known as co-transport.

It can be of following three types

a. Symport

In this, both molecules cross the membrane in the same direction.

b. Antiport

In this both molecules cross membrane in opposite directions.

c. Uniport

In this type, the molecules moyes across a membrane independent of any other molecules

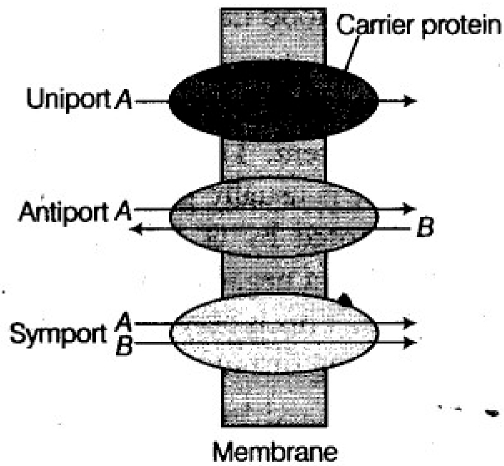


Fig. 11.2 Facilitated diffusion

3. Active Transport

Active transport uses energy in the form of ATP to pump molecules or ions against a concentration gradient (i.e., uphill transport low concentration to high concentration). This is carried out by the carrier proteins in the plasma membrane. "When the transporters become saturated or are used up the rate of transport reaches its maximum level.

These carrier proteins are very specific in carrying protein across . the membrane. The ions once transported inside the membrane cannot return back to the outer space. While the carrier protein returns back to its original state in order to pick new ion or a molecule. These carrier proteins are very sensitive to inhibitors or other substances, which have the property of reacting with side chains of the proteins.

Comparison of Different Transport Processes

Out of the transport mechanisms discussed above, diffusion (whether facilitated or not) takes place along a concentration gradient without the utilisation of energy. However, both facilitated diffusion and active transport are mediated through membrane proteins.

Protein transporters are highly selective in nature, liable to get saturated, respond to inhibitors and are under hormonal regulation.

Comparison of Different Transport Process

Property	Simple Diffusion	Facilitated Diffusion	Active Transport
Requires special membrane proteins	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Requires ATP energy	No	No	Yes

Plant Water Relations

Before discussing how absorption and transportation of water takes place in plants. It is necessary to understand some basic facts about water. Without the constant supply of water, the plant could not carry on any of its physiological activities.

Some useful functions of water are given below

(i) Water carries the nutrients from the soil to the plants.

(ii) Water acts as a major component of all living cells, i.e., a medium in which all substances are dissolved and undergo various types of reaction, e.g., protoplasm of cells is nothing but water containg several different molecules or suspended particles.

(iii) It acts as an excellent solvent and also acts as cooling system in plants.

(iv) Every plant whether herbaceous or woody consists of water but its amount varies, e.g., Herbaceous plant has 10-15% of its fresh weight as dry matter watermelon has 92% of water while woody plants has relatively very little water .

(v) It also acts as a major component of seeds (for their survival and respiration) although they appear dry.

(vi) It acts as a limiting factor for growth and productivity of plant in both agricultural and natural environments because of high demands of water by plants.

Note:

- A mature corn plant absorbs almost three litres of water in a day, while a mustard plant absorbs water equal to its own weight in about 5 hrs.
- Terrestrial plants take up huge amount water daily but most of it is loss to the air through transpiration (i.e., evaporation from the leaves).
- To understand plant water relation an understanding of action standard terms like water potential, solute potential, pressure potential etc

Water Potential

Potential is the way of representing free energy. All living organisms require free energy to grow, maintain metabolism and reproduce. As water molecules possess kinetic energy, they are in random motion (in both liquid and gaseous form) which is rapid and constant.

Thus, water potential is the difference between the free energy of water molecules in pure water and the energy of water in any other system. It is denoted by (psi) and expressed in pressure unit i.e., pascals (Pa). Greater the concentration of water in a system, greater will be its kinetic energy or water potential, i.e., pure water will have greatest water potential.

The best way to express spontaneous movement of water from one region to another is in terms of differences in the free energy of water between two region, i.e., one with the higher energy to one with the lower energy.

Thus, water will move from the system containing water with higher potential to the one having lower potential (down the gradient). Hence, this movement of water is called diffusion.

Note:

- The term water potential was first used by Slatyer and Taylor.
- By convention, the water potential of pure water at standard temperatures, which is not under any pressure, is taken to be zero.
- Water potential is always regarded as the tendency of water to leave a system.

Solute Potential

The magnitude by which water potential is reduced due , to the presence of a solute in pure water is known as solute potential. When solute or some substance is dissolved in pure water, the concentration of water decreases and solution will have fewer free water. It infers that the presence of solute particles in water reduces the free energy of water due to which water potential also decreases.

Solute potential is denoted by \J/S and is always negative (or has value less than zero). Hence,
More number of solute molecules = Lower solute potential (more — ve).
At atmospheric pressure for a solution

$$\underset{\text{(Water potential)}}{\Psi_w} = \underset{\text{(Solute potential)}}{\Psi_s}$$

Pressure Potential
If a pressure more than atmospheric pressure is applied to pure water or a solution (containing solute), the water potential increases. This is equal to pumping water from one place to another such as our heart buildup pressure for the circulation of blood in the body.

When water enters a plant cell through diffusion, it becomes turgid due to building up of pressure against the cell wall in a plant system. This leads to increase in the pressure potential. It is usually positive known a turgor pressure and is denoted by fp. Loss of water during transpiration produces a negative hydrostatic pressure or tension in the xylem. This is very important in transport (Asent of sap) over long distances in plants.
Water potential is affected by both solute and pressure potential.

$$\Psi_w = \Psi_s + \Psi_p$$

Osmosis
A plant cell is surrounded by both cell wall and cell membrane. The cell wall is freely permeable, i.e., it does not act like a barrier to the movement of water and other substances. The cell membrane and membrane of vacuole, the tonoplast are responsible for determination of water or other molecules in or out of the cell.

The large central vacuole and its contents (vacuolar sap) contributes to the solute potential of the cell.
Osmosis may be defined as the net movement of solvent molecules (water molecules) across a differentially or semipermeable membrane.

Osmosis takes place very spontaneously in response to a driving force.
The movement of solvent, in osmosis occurs due to the differences of water potential on two sides, i.e., water will move from a region of higher chemical potential to a region of lower chemical potential until the state of equilibrium is reached.

The net direction of molecules and rate of osmosis depends on two factors
(i) Pressure gradient
(ii) Concentration gradient.
Osmosis is a passive process and does not require any input of energy. Discovery of osmosis was made by Pfeffer.

Illustration of Osmosis
Phenomenon of osmosis can he easily understood on the basis of the diagram given below

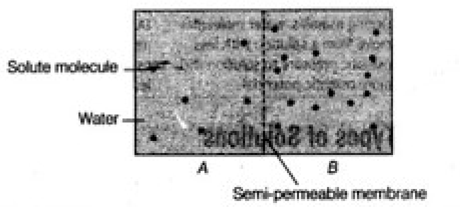


Fig.11.3 Two chambers *A* and *B* containing solutions separated by a semi-permeable membrane

On the basis of this following observations are made
(i) Solution in chamber B has a lower water potential (as it contains more number of solute particles
than A).
(ii) Solution in chamber A has a lower solute potential (as it has less number of solute particles, than B chamber) and B chamber has higher solute potential (as it contains high solute particles and less solvent, i.e., water).

(iii) Osmosis will takes place from chamber A —> B because as explained earlier osmosis always occurs from its region of higher chemical potential to a region of lower chemical potential.
One must not be confused with the movement of solvent (water) and movement of solute (water + solute particles) as solute always moves from a region of lower concentration to higher concentration and vice-versa in the case with solvent

(iv) At equilibrium, both chambers will have same water potential (i.e., neither A and B will have lower or higher water potential).

Note:
Endosmosis and Exosmosis The inflow of solvent (water) into a cell from outside when placed in distilled water, is called endosmosis in which cells swell up due to the entry of water and become turgid.

On the other hand, the outward flow of water from cell when placed in hypertonic solution like sugar solution, the cell tends to shrink and becomes flaccid. This outward flow of water in solution is called exosmosis.

The Funnel Experiment
This is another experiment, which is performed in the laboratory through which phenomenon of osmosis can be easily demonstrated.

Following steps are performed during this experiment
(a) A beaker is taken and filled with pure water.
(b) A thisde funnel is filled with sucrose solution and kept inverted in a beaker containing water (level is noted).
(c) The inverted funnel is separated from a pure water through a semi-permeable membrane.
(d) Level of the sucrose solution will rise into the funnel as water will move into the funnel as shown in fig (a).
(e) Water will continue moving till an equilibrium state is achieved.
If sucrose will diffuse out through the membrane, the equilibrium will not be reached ever, because for the state of equilibrium the concentration or gradient potential should be equal in both the chambers, i.e., funnel and beaker.
(f) External pressure is applied from the upper part of the funnel as in fig.(b) to stop the water movement into the funnel through the membrane.

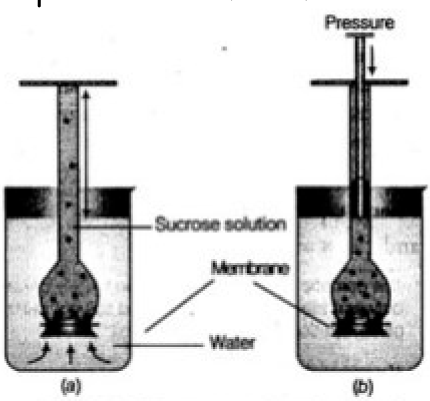


Fig. 11.4 Demonstration of osmosis
A thistle funnel is filled with sucrose solution and kept inverted in a beaker

Differences between Diffusion and Osmosis

Diffusion	Osmosis
It is the movement of molecules or ions from a zone of high to low concentration or from a zone of their higher free energy to a zone of lower free energy, until they are evenly spread in the media.	It is the movement of solvent (water) molecules from a zone of higher free energy to a zone of lower free energy through a semipermeable membrane.
Can occur in any type of medium solid, liquid or gaseous.	Occurs only in liquid medium.
Semipermeable membrane not involved.	Semipermeable membrane is involved.
It is just dependent on the free energy of diffusing molecules.	It is dependent upon the free energy of solvent molecules present on both sides of the membrane.

Significance of Osmosis

Osmosis is helpful in many ways as given below

(i) It helps in maintenance of cell turgidity.

(ii) Plays a vital role in stomatal movement during transpiration.

(iii) It helps in the movement of liquids across biological membranes.

(iv) It also have effects on absorption of water by roots.

Osmotic Pressure

It is that pressure of a solution, which must be applied to the solution in order to allow passage of solvent due to osmosis. This is also the function of solute concentration; i.e., more the concentration of a solute, greater will be the amount of pressure applied in order to prevent water from diffusing. Osmotic pressure is numerically equal to the osmotic or solute potential but osmotic potential has a negative sign, while osmotic pressure is always a positive pressure.

i.e., $\psi_s = -\pi$

where, ψ_s = solute potential

and π = osmotic pressure

The osmotic pressure of a solution largely depends upon the ratio between the number of solute and solvent particles present in a given solution.

Note:

- Instrument used for measuring osmotic pressure is called osmometer, eg., Berkeley and Hartleys osmometer.
- Reverse osmosis is expulsion of pure water from solution through a semipermeable membrane under the influence of external pressure, higher than OP of solution.

Differences between Osmotic Pressure and Osmotic Potential

Osmotic Pressure	Osmotic Potential
It is the pressure which must be applied in order to prevent the passage of solvent due to osmosis.	It is the amount by which water potential is reduced as a result of presence of solutes.
Its unit is bars with positive sign.	Its unit is bars with negative sign.
Osmotic pressure of pure solvent (water) is zero. The value increases due to addition of solute particles.	The value of pure solvent (water) is also zero. Addition of solute particles makes the value of the osmotic potential more negative.
During osmosis, water molecules move from a solution with less osmotic pressure to solution with more osmotic potential.	During osmosis, water molecules move from a solution with more osmotic potential to solution with less water potential.

Types of Solutions

The plant cells or tissues behave according to the movement of water depending upon the surrounding solution. Thus, on the basis of concentration of cell sap (cellular solution found in large central vacoule of a living plant cells).

The solutions are of following three types (i) Isotonic Solution It is a type of solution, which has a similar concentration as the cell sap of the cells, i.e., No change occurs in a cell after placing it in isotonic solution.

(ii) Hypotonic Solution It is a type of solution which has lower concentration (more diluted) than the cell sap. The cell swells up when placed in this solution.

(iii) Hypertonic Solution It is a type of solution which has higher concentration than the cell sap of cells. The cells shrink, when placed in hypertonic solution.

Note:

The term 'Diffusion Pressure Deficit' (DPD) was coined by BS Meyer in 1938. The amount by which diffusion pressure of a solution is lower than that of its pure solvent is known as diffusion pressure deficit.

DPD= OP– TP (WP)

Fully turgid cell

DPD= O

OP= TP

fully flaccid cell

TP= O

DPD= OP

Plasmolysis

This phenomenon occurs when water moves out of the cells and the cell membrane of a plant cell shrinks away from its cell wall when placed in a hypertonic solution (having more concentration). During the process the hypertonic solution causes exosmosis (outward movement of water).

The water first moves out from the cytoplasm and then from the central vacoule. This withdrawal of water through diffusion into the extracellular fluid causes the cell to shrink in size, due to which cell moves away from the walls. The cells is said to be plasmolysed.

The space between the cell wall and the shrunken protoplast is occupied or filled by the eternal solution.

At limiting plasmolysis the pressure of external solution balances the osmotic pressure of the cytoplasm. Thus, during this state of equilibrium when flow of water into and out of the cell is same, the cells are called flaccid.

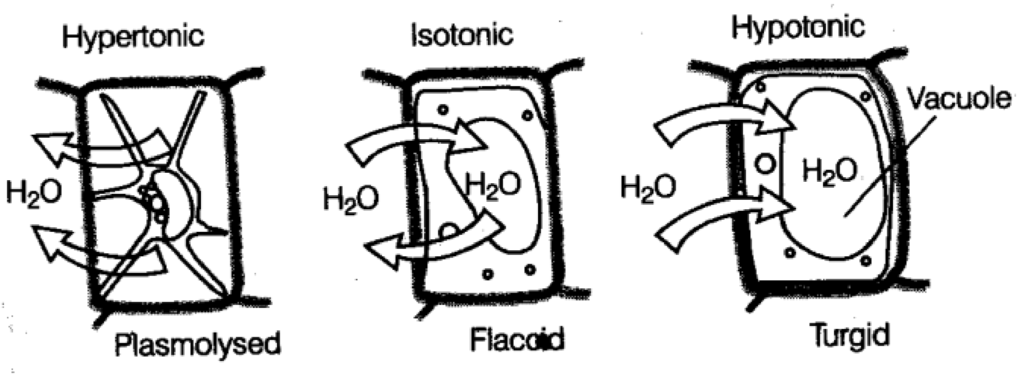


Fig. 11.5 Plant cell plasmolysis

Deplasmolysis

The process in which the plasmolysed cell when placed in pure water or hypotonic solution, builds up a turgor pressure (in which water enters the cell and cause the cytoplasm to build up a pressure against the wall). It is mainly responsible for enlargement and extensive growth of the cells. During this stage, water enters due to endosmosis and cell again becomes turgid when protoplast attains its original shape and size. As cell wall is rigid, the cell do not rupture. The pressure exerted against rigid wall due to the entry of water by the protoplasts is called pressure potential, i.e., fp .

(i) Deplasmolysis should be followed immediately after plasmolysis otherwise the cell protoplast becomes damaged permanently.
(ii) Pressure potential of a flaccid cell is zero because there is no net movement of water in and out of the cell.
(iii) Cell wall is found in bacteria, fungi, algae some archea and plant cells (animals and protozoans do not have cell wall).

Differences between Plasmolysis and Deplasmolysis

Plasmolysis	Deplasmolysis
It occurs when a tissue is placed in hypertonic solution.	Deplasmolysis occurs when freshly plasmolysed cells are kept in hypotonic solution or pure solvent.
Plasmolysis is a result of exosmosis.	Deplasmolysis is a result of endosmosis.
Plasmolysis involves shrinkage of protoplast from the cell wall.	It is swelling of shrunken protoplast so as to come in contact with cell wall.
Plasmolysis is not reversible after a long interval of time.	Deplasmolysis is reversible even after an interval.

Significance of Plasmolysis

(i) It allows a plant cell to lose water without dying, it can shrink or increase in size as water is available within the constraints of the cell wall.
(ii) It is shown by living cells. By this we can determine whether a cell is living or dead.
(iii) It helps in determining osmotic pressure of plants.
(iv) It proves that cell wall is elastic and permeable.

Imbibition

It is a special phenomenon in which water or any other liquid is absorbed by the solid particles (colloids) of a substance. This leads them to increase enormously in volume. The solid particles which imbibe water or any other liquid are called imbibants. The liquid, which is imbibed is known as imbibate. It is also a type of diffusion because movement of water occur along concentration gradient as in diffusion. During imbibition, water molecules get tightly adsorbed and becc immobilised.

Note:

- During imbibition water molecule lose most of their kinetic energy in the form of heat. This is called heat of hydration or heat of wetting
- Imbibition can be best explained and seen in absorption of water by seeds and drywood which acts as absorbents to imbibe water and swell.

Imbibition Pressure

The pressure developed by solid particles, which adsorbs water or any other liquid when submerged in pure imbibing liquid is called imbibition pressure. It is due to this pressure in plants that seedlings emerge out of the soil and establish themselves.

Conditions necessary for imbibition to take place are

(i) Affinity between the adsorbant and the liquid imbibed is essential.

(ii) Water potential gradient between the absorbent and the liquid imbibed.

The phenomenon of imbibition is also influenced by several factors like temperature (increases with rise in temperature), pressure (decreases if pressure is against imbibant), pH (depends on change of imbibant) electrolytes (decreases) and texture of imbibant (increases if it is loose, decreases if it is compact in nature).

Importance of Imbibition

Imbibition plays following major roles

(i) Helps seedlings to come out of soil.

(ii) Acts at the initial stage in germination of the seeds.

(iii) Helps of seeds.

(iv) In older times, the imbibition pressure was used in breaking the rocks and stones.

(v) It is dominant in the initial stage of water absorption by roots.

Differences between Imbibition and Diffusion Imbibition Diffusion

Imbibition	Diffusion
In this the absorption of solvent or water takes place by a solid substances.	It is the movement of substances from the region of their higher concenteration to the region of their lower concentration.
It always results in the release of heat (called heat of wetting or heat of hydration).	It does not involve the release of heat.
The molecules of water or any other liquid are adsorbed to the surface of hydrophilic colloids (e.g., cellulose, starch, proteins, polypeptides, etc).	The diffusing particles/molecules distributed uniformaly throughout the available space.
The imbibant swells up but the swelling is less than volume of imbibate.	No overall change in volume is seen
It occurs only when an adsorbant (imbibant) is present.	There is no requirement of any adsorbant.
It develops a very high pressure (up to 1000 atm).	It develops less pressure comparatively (upto 100 atm).

Note:
Adsorption is property of colloids. Hence, material which have high proportion of colloids are good imbibants. eg., wood, is good imbibant as it contains proteins, cellulose and starch as colloidal substances.

Topic 2 Long Distance Transport of Water

Long distance transport of substances cannot take place by the process of diffusion alone. Diffusion accounts for only those molecules that move for short distance and it is a very slow process. For instance, the movement of a molecule across a typical plant cell (about 50 pm) takes approximately 2.5 second. At this rate, the movement of molecules over a distance of 1 m would take approximately 32 years by diffusion alone.

In large and complex organisms, sites of production or absorption and sites of storage are far away from one another thus, the substances to be transferred have to follow a long path and move across very large distances.
Hence, some special long distance transport systems are necessary in order to transfer substances across long distances at much faster rate.

The movement of water, minerals and food across long distances is generally done by a mass or bulk flow system, which operates due to difference between the pressure of two points, i.e., the source and the sink. The substances whether dissolved or suspended in solution, are carried at a same speed. Such a movement is different from diffusion where different substances move independent of each other depending upon concentration gradients of their own. Mass or bulk flow movement occurs through vascular tissues, xylem and phloem of plants. The bulk movement of substances through conducting or vascular tissues of plant is called translocation.

There are generally two types of vascular tissues in plants which are responsible for translocation
(i) Xylem It is responsible for translocation of water with mineral salts, some organic nitrogen and hormones mainly from roots to aerial parts of plants.
(ii) Phloem It is responsible for translocation of organic and inorganic substances from leaves to other parts of the plant. Bulk flow can operate either due to positive hydrostatic pressure gradient (like a garden hose) as in phloem or a negative hydrostatic pressure gradient (like suction through a straw) as in xylem.

Absorption of Water by Plants
Plants absorb water through roots. However, the area of young roots where most absorption of water and minerals takes place is root hair zone. Root hairs are thin walled, slender extension of root epidermal cell present at the tip of the roots in millions. These are very delicate structure, which do not last for more than days or a week. They have very sticky walls that help in tight adhesion to the soil particles.

Tracheids and trachea of xylem transport water in plants.
Water once absorbed by file root hairs enter epidermis from where, it moves deeper into the root layers and finally reaches xylem following two pathways, i.e., apoplast and symplast.

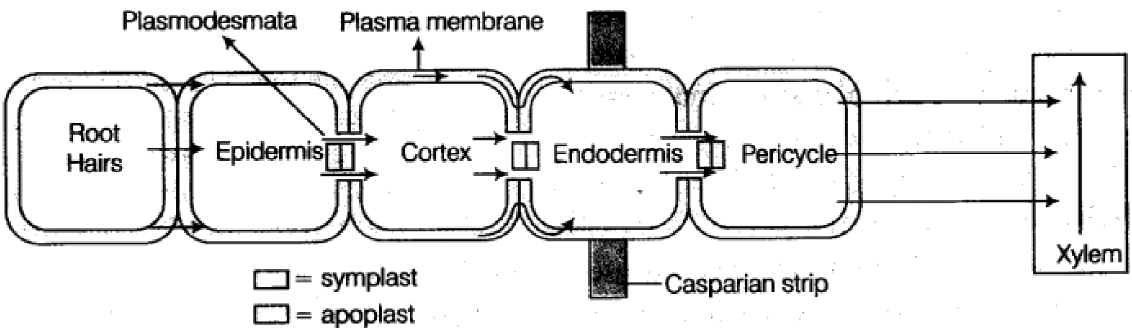


Fig. 11.6 Pathway of water movement in the root

Apoplast Pathway
Apoplast is the system of adjacent cell walls (i.e., interconnecting cell walls, intercellular spaces, cell wall of endodermis) that occur continuously throughout the plant, except at the casparian strips of endodermis in roots. In this pathway, the movement of water molecules takes place through intercellular spaces and the walls of the cells only. The water movement takes place along the gradient" from root hairs to xylem through the walls of intervening cells without crossing any

membrane or cytoplasm.Thus, it does not provide any barrier to the movement of water, which occur through mass flow , due to adhesion and cohesion of water molecules.
There is no involvement of osmosis in the apoplast pathway.

Symplast Pathway
This system includes the living part of the plant cells made up of interconnected protoplasts of neighbouring cells and connected through cytoplasmic strands extending through plasmodesmata.

The water that enters into the cell sap of root hair as a result of active absorption, moves into the underlying cortex cells bounded by a continuous selectively permeable membrane through plasmodesmata.

The movement is relatively slower as water enters the cells through the cell membrane. The movement is again down the potential gradient. This pathway is aided by cytoplasmic streaming, which helps in quicker movement across individual cells. Thus, facilitating transport.

Cytoplasmic Streaming is an autonomous vital movement that occurs in eukaryotic cells continuously, e.g., around the central vacuole. Also known as cyclosis. It can be easily observed in the cells of Hydrilla leaf. The movement of chloroplast due to streaming is easily seen under microscope.

It is generally believed that both apopiast and symplast pathways are operative in plants but apopiast pathway offers less or no resistance. Thus, water continue to move through apopiast in the roots.

As the apopiast pathway is bfbcked by the bond of a suberised matrix called the casparian strip in the inner boundary of the cortex, the endodermix is imperious to water.

Therefore, the movement of water by and the endodermis occurs by the symplast pathway, i.e., water from the cell walls enter the cell cytoplasm and moves from one cell cytoplasm to another cell cytoplasm crossing the cell membrane through plasmodesmata and finally reaches the xylem elements.

Mycorrhizal Absorption

Instead of using root hairs for absorption many plants use mycorrhiza for water absorption. Mycorrhiza is a symbiotic association between a fungus and a young root system of a plant. Fungal hyphae have a very large surface area and extend into soil for sufficient distance, where a root cannot reach.

They absorb both mineral ions and water from the soil and provide these substances to the roots. The roots in turn provides sugar and N-containing compound to the mycorrhizae. The mycorrhizal association is obligate in many cases, e.g., seeds of Pinus and many orchid cannot ' germinate properly without the development of mycorrhizal association.

Water Movement up a Plant (Ascent of sap)
Translocation of water or ascent of sap is usually upwards from the roots toward the top of the plant via stem, i.e., to the leaves and growing points or apical meristems and other aerial plant parts. It occurs through the tracheary elements of xylem. Many theories have been put forward to explain the upward movement of water.

Two of them are given below
Boot Pressure
It is believed that all plants absorb excess of water by an active process and tends to build up a positive hydrostatic pressure within the root system known as root pressure. Due to this activity the water is pushed upward along the length of the stem to a small height. The pressure inside the xylem is caused due to the diffusion pressure gradient and is maintained by the activity of living cells.

Demonstration of Root Pressure in Plants
At the start of the experiment, choose a plant having soft stem on a day when there is plenty of moisture in the atmosphere. Early in the morning cut the stem horizontally near the base, i.e., just above the soil with a sharp blade. The moment cut is made, few drops of solution start oozing out of the cut stem, which is due to the positive root pressure. Now in order to determine the rate of exudation (substances that oozes out) and the composition of the exudates (like sap, germs, latex, etc.), fix a vertical glass tuBe filled with water, with the help of a rubber tube to the cut end the stem. A column of sap is seen to ripe in the tube, which will be the measure of the root pressure.
Root pressure is inhibited or reduced during reduced aeration, low or high temperature, drought, etc.
Root pressure is maximum during early morning of spring and – rainy season when

the level of evaporation is low or minimum and decreases with the advancement of day.
The magnitude of root pressure is about two bars or atmospheres.

Guttation

- When the amount of root pressure is high and rate of itranspiration is low, many herbaceous plants tend to loose small quantities of water or liquid in the form of drops from the hydathodes (small pores) or water glands. These are present on the margins of the leaves or where the main vein ends and near the tips of blades of some vascular plants like i i grasses and small herbaceous plants (rose, strawberry, tomato, etc).
- This phenomenon water loss in its liquid phase is called guttation. It takes place usually in early morning. The water that oozes out contains organic-and inorganic substances.

Contribution of Root Pressure
As root pressure contribute a modest push in the overall water transport. The enormous tension developed by transpiration, breaks the continuous chains of water molecules in the xylem which gets re-establish by the root pressure. In this way root pressure provides a great contribution in the transport of water.

Limitations to Root Pressure
Root pressure cannot account for the translocation of water or ascent of sap due to the following reasons
(i) It cannot lift sufficient amount of water upward to meet the requirement of water.
(ii) It fails to play a role in water movement in tall trees like gymnosperms, etc.
(iii) The amount of the fluid transported by the root pressure is not enough in measuring the movement of water in xylem in many trees.
(iv) Root pressure seems to be absent in summer when the requirements of water are high.
Although it plays a major role in the transport of water through xylem in some plants and some seasons but it does not account for majority of water transport due to which most plants fulfil their needs by transpiratory pull.

Transpiration Pull
Plants have a continuous water column in their xylem channels that starts at the base, i.e., roots and continues up to leaves from where water is lost through the

process of transpiration. Thus, despite the absence of a circulatory system in plants, the flow of water upward through the xylem in plants achieve fairly high rates up to 15 meters per hour.

The water molecules in the water column remain attracted by the cohesive force and cannot be separated easily from one another. Thus, there is attraction between water molecules and the inner wall of xylem ducts. Hence, water column cannot be pulled away from the walls of xylem ducts due to strong adhesive and cohesive forces. This maintains the continuity of water column from roots to leaves.

Water is lost from mesophyll cells to the inter cellular spaces as a result of transpiration and develops a strong negative water potential. There are very large number of leaves and each leaf has thousands of transpiring mesophyll cells, which withdraw water from the xylem. This leads to a negative pressure in the water column, which exerts an upward pull over the water column. This pull is known as transpirational pull.

This tension or pull is transmitted up to the roots in search for more water. The water column (formed in the xylem elements of roots) now moves upward under the influence of transpirational pull.

Thus, the cohesive, adhesive forces and transpiration pull all help in lifting up of water through xylem elements and because of the critical role of cohesion the transpiration pull is also called cohesion-tension transpiration pull model of water transport.

Note:

Cohesion-tension theory was originally proposed by Dixon and Jolly in 1894 and further improved by Jolly in 1914.

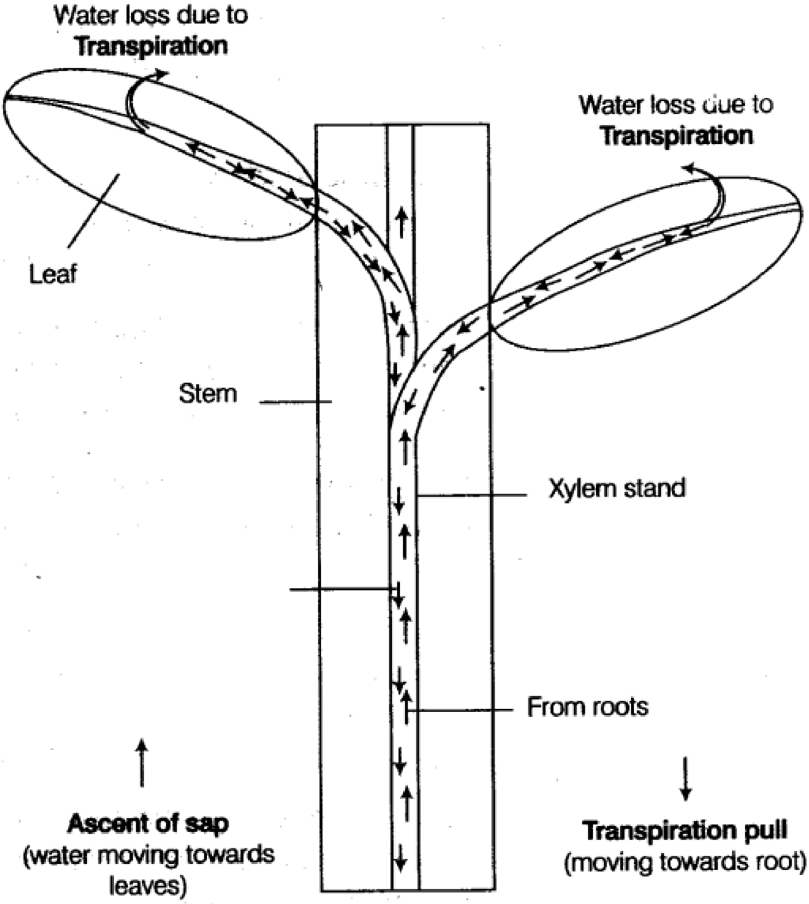


Fig. 11.7 Transpiration pull (tension) and ascent of sap

Transport in Plants Class 11 MCQs Questions with Answers

Question 1.
Dry seeds kept in water swell due to
(a) absorption
(b) diffusion
(c) imbibition
(d) none of these

Answer

Answer: (c) imbibition
Explanation:
Imbibition is a type of diffusion in which water is absorbed by solids or colloids which leads to increase in volume. This happens in case of dry wood and seeds.

Question 2.
Choose the correct statement/statements. Pumps in active transport are A. Lipids that bind molecules to pass them through the membrane. B. Transport molecules uphill. C. These are specific transporters. D. These are sensitive to inhibitors.
(a) A and C
(b) A, B and D
(c) B, C and D
(d) C and D

Answer
Answer: (c) B, C and D
Explanation:
Pumps in active transport are proteins that bind molecules to pass them through the membrane.

Question 3.
Which of the following is the unit of ψ?
(a) Pascal
(b) Joule
(c) Newton
(d) Electron volt

Answer
Answer: (a) Pascal
Explanation:
Psi or ψ is expressed in pressure units e.g. pascals.

Question 4.
Two cells A and B are contiguous. Cell A has osmotic pressure 10 atm, turgor pressure 7 atm and diffusion pressure deficit 3 atm. Cell B has osmotic pressure 8 atm, turgor pressure 3 atm and diffusion pressure deficit 5 atm. The result will be:
(a) No movement of water
(b) Movement of water from cell B to A

(c) Movement of water from cell A to B
(d) Equilibrium between the two

Answer
Answer: (c) Movement of water from cell A to B

Question 5.
Which of the following is decreased during increase in humidity in the atmosphere?
(a) Transpiration
(b) Photosynthesis
(c) Respiration
(d) Glycolysis

Answer
Answer: (a) Transpiration
Explanation:
With the increase in humidity in atmosphere, rate of transpiration decreases.

Question 6:
Ψ_s is always
(a) positive
(b) zero
(c) negative
(d) one

Answer
Answer: (c) negative
Explanation:
Ψ_s is always negative.

Question 7.
Two types of molecules cross the membrane in the same direction, it is called as
(a) Uniport
(b) Symport
(c) Antiport
(d) Multiport

Answer

Answer: (b) Symport
Explanation:
In symport, two types of molecules cross the membrane in the same direction.

Question 8.
Diffusion rate is affected by
(a) temperature
(b) membrane permeability
(c) gradient of concentration
(d) all of these

Answer
Answer: (d) all of these
Explanation:
Diffusion rate is affected by the gradient of concentration, permeability of the membrane separating them, temperature and pressure.
Question 9.
Cells shrink in __________ solution.
(a) isotonic
(b) hypotonic
(c) hypertonic
(d) hypotonic and hypertonic

Answer
Answer: (c) hypertonic
Explanation:
In hypertonic solution, external solution is more concentrated as compared to cytoplasm.
Cells shrink in hypertonic solutions.

Question 10.
Which of the following is true about diffusion?
(a) There is no expenditure of energy.
(b) Molecules move in Brownian motion.
(c) Substances moves from the region of higher concentration to the region of lower concentration.
(d) Diffusion depends on the type of living system.

Answer
Answer: (d) Diffusion depends on the type of living system.
Explanation:
Diffusion is a slow process, it is not dependent on the living systems.

Question 11.
Which of the following is true about diffusion?
(a) There is no expenditure of energy.
(b) Molecules move in Brownian motion.
(c) Substances moves from the region of higher concentration to the region of lower concentration.
(d) Diffusion depends on the type of living system.
Answer
Answer: (d) Diffusion depends on the type of living system.
Explanation:
Diffusion is a slow process, it is not dependent on the living systems.

Question 12.
Water is lost in a liquid state in some plants through hydathodes. These hydathodes
(a) do not show any specificity in opening and closing
(b) remain closed during day
(c) remain closed at night
(d) remain always open
Answer
Answer: (d) remain always open

Question 13.
If pressure greater than atmospheric pressure is applied to pure water, the water potential
(a) increases
(b) decreases
(c) remains same
(d) atmospheric pressure does not affect water potential

Answer
Answer: (a) increases
Explanation:

If a pressure greater than atmospheric pressure is applied to pure water, the water potential increases.

Question 14.
Choose the correct sequence of water movement in the plants.
(a) Cortex, protoxylem, endodermis, root hair, pericycle, metaxylem
(b) Root hair, cortex, endodermis, pericycle, protoxylem, metaxylem
(c) Root hair, protoxylem, metaxylem, pericycle, cortex, endodermis
(d) Root hair, pericycle, endodermis, cortex, protoxylem, metaxylem

Answer
Answer: (b) Root hair, cortex, endodermis, pericycle, protoxylem, metaxylem
Explanation:
Water is absorbed from soil by root hair. This is then carried by cortex,then passed to endodermis.
Endodermis passes water to Perivale then to protoxylem and metaxylem.

Question 15.
Wilting of a plant results from excessive
(a) respiration
(b) photosynthesis
(c) absorption
(d) transpiration

Answer
Answer: (d) transpiration
Question 16.
Cohesion theory of water movement in plants was put forth by
(a) Henry Dixon
(b) F. F. Blackman
(c) Melvin cycle
(d) Hans. A. Krebs
Answer
Answer: (a) Henry Dixon
Question 17.
Diffusion rate is affected by
(a) temperature
(b) membrane permeability

(c) gradient of concentration
(d) all of these

Answer
Answer: (d) all of these
Explanation:
Diffusion rate is affected by the gradient of concentration, permeability of the membrane separating them, temperature and pressure.

Question 18.
When a plant is girdled (ringed)
(a) the root and shoot die at the same time
(b) the shoot dies first
(c) the root dies first
(d) neither root nor shoot will die

Answer
Answer: (c) the root dies first

Question 19.
Choose the correct statement/statements. Pumps in active transport are A. Lipids that bind molecules to pass them through the membrane. B. Transport molecules uphill. C. These are specific transporters. D. These are sensitive to inhibitors.
(a) A and C
(b) A, B and D
(c) B, C and D
(d) C and D

Answer
Answer: (c) B, C and D
Explanation:
Pumps in active transport are proteins that bind molecules to pass them through the membrane.
Question 20.
Assertion (A): K+ ion accumulation found in Nitella depends on its respiratory activity. Reason (R): Absorption of all ions in plants completely depends on the usage of metabolic energy. The correct answer is
(a) A and R are true and R is the correct explanation of A

(b) A and R are true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true
Answer
Answer: (c) A is true but R is false

Solutions for Class 11 Biology Chapter 11 Transport in Plants:

Section Name	Topic Name
11	Transport in Plants
11.1	Means of Transport
11.2	Plant-Water Relations
11.3	Long Distance Transport of Water
11.4	Transpiration
11.5	Uptake and Transport of Mineral Nutrients
11.6	Phloem Transport: Flow from Source to Sink
11.7	Summary

TEXTBOOK QUESTIONS SOLVED

1.What are the factors affecting the rate of diffusion?

Solution. Factors affecting the rate of diffusion are :

- Density – Rate of diffusion of a substance is inversely proportional to square root of its relative density (Graham's Law).
- Permeability of medium – Rate of diffusion decreases with density of the medium.
- Temperature – A rise in temperature increases the rate of diffusion with Q_{10} = 1.2 -1.3. Because of it sugar crystals do not dissolve easily in ice cold water while they do so easily in warm water.
- Diffusion pressure gradient – Rate of diffusion is directly proportional to the difference of diffusion pressure at the two ends of a system and inversely proportional to the distance between the two.

2.What are porins? What role do they play in diffusion?

Solution: The porins are proteins that form huge pores in the outer membranes of the plastids, mitochondria and some bacteria allowing molecules up to the size of small proteins to pass through. Thus they play an important ' role in facilitated diffusion.

3.Describe the role played by protein pumps during active transport in plants.

Solution: Active transport uses energy to pump molecules against a concentration gradient. Active transport is carried out by membrane play a major role in both active as well as passive transport. Pumps are proteins that use energy to carry substances across the cell membrane. These pumps can transport substances from a low concentration to a high concentration ('uphill' transport).

E.g.,H^+ pump,K^+ pump, Cl- pump, Na+-K pump.The pumps operate with the help of ATP.K^+-H^+ exchange pump occurs in guard cells. Na^+-K^+ exchange pump operates across many animal membranes. Transport rate reaches a maximum when all the protein transporters or pumps are being used or are saturated.Like enzymes these carrier proteins are very specific in what they carry across the membrane. These proteins are sensitive to inhibitors that react with protein side chains.

4. Explain why pure water has the maximum water potential.

Solution: Water molecules possess kinetic energy. In liquid and gaseous form they are in random motion that is both rapid and constant. The greater the concentration of water in a system, the greater is its kinetic energy or 'water potential'. Hence, it is obvious that pure water will have the greatest water potential. Water potential is denoted by the Greek symbol Psi or ψ and is expressed in pressure units such as pascals (Pa). By convention, the water potential of pure water at standard temperatures, which is not under any pressure, is taken to be zero. If some solute is dissolved in pure water, the solution has less free water and the concentration of water'decreases, reducing its water potential. Hence, all solutions have a lower water potential than pure water.

5.Briefly describe water potential. What are the factors affecting it?

Soln. The term water potential was first used by Slatyer and Taylor (1960). The free energy per mole of any particular chemical species in a multicomponent system is defined as the chemical potential of that species. The chemical potential of water is referred to as the water potential (ψ_w). Since the ψ of pure water is zero (0), the presence of solute particles reduces the free energy of water, thus decreases the water potential (negative value). Therefore,ψ of solution is always less than zero or its highest value is zero.

For solutions water potential is determined by three internal factors, i.e.,$\psi_w = \psi_m + \psi_s + \psi_p$ (where ψ_m is matric potential which is used for the surface such as soil particles or cell wall to which water molecules are absorbed, $\psi_s$is solute potential, also called osmotic potential, the amount by which water potential is reduced and ψ_p is pressure potential such as TP and WP). Since in plant system ψ_m is disregarded the equation may be simplified as :

$\psi_w = \psi_s + \psi_p$

6. What happens when a pressure greater than the atmospheric pressure is applied to pure water or a solution?

Solution: If a pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential increases. It is equivalent to pumping water from one place to another. Pressure can build up in a plant system when water enters a plant cell due to diffusion causing a pressure built up against the cell wall, it makes the cell turgid.

7. (a) With fhe help of well-labelled diagrams, describe the process of plasmolysis in plants, giving appropriate examples.
(b) Explain what will happen to a plant cell if it is kept in a solution having higher water potential.

Soln.(a) Shrinkage of the protoplast of a cell from its cell wall under the influence of a hypertonic solution is called plasmolysis. Hypertonic solution causes exosmosis or withdrawal of water from cytoplasm and then the central vacuole of cell. The size of cytoplasm, as well as central vacuole and hence protoplast, becomes reduced. The first stage of plasmolysis is called limiting plasmolysis. At limiting plasmolysis, the pressure potential (ψ_p) is zero and the osmotic concentration of cejl interior is just equivalent to that of external solution (isotonic). The cell is called flaccid. When pressure potential becomes negative, the protoplast withdraws itself from the comers. This stage is known as incipient plasmolysis. At incipient plasmolysis, the cell wall exerts no pressure on the cell contents (i.e. ψ_p is zero). Hence at this stage $\psi_w = \psi_s$. The hypertonic solution now enters the cell in between the protoplast and the cell wall. Due to continued exosmosis, protoplast shrinks further and withdraws from the cell wall except one or a few points. It is known as evident plasmolysis.

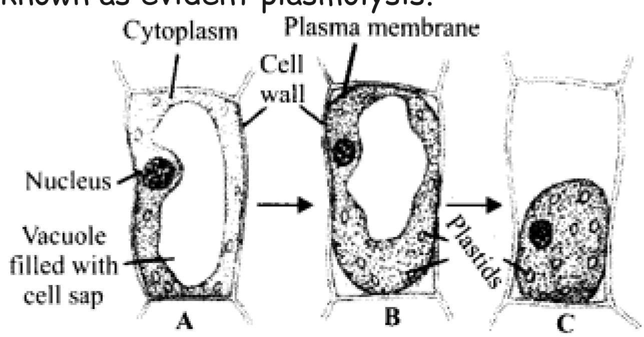


Fig.: Various stages in plasmolysis: A. Normal cell; B. Incipient plasmolysis; C. Plasmolysed cell.

Examples of plasmolysis :
(i) Pickles, meat and fish are preserved by salting. Similarly, jams and jellies are preserved by sweetening with sugars. Salting and sweetening create hypertonic condition in which the fungi and bacteria get killed by plasmolysis.
(ii)Salting kills the weeds of lawns by inducing plasmolysis in their cells.
(iii)Plasmolytic method is applied for the determination of osmotic pressure of a cell in the laboratory.
(b) When the cells are placed in a solution having higher water potential i.e., hypotonic solution (dilute solution as compared to the cytoplasm), water diffuses into the cell causing the cytoplasm to build up a pressure against the wall, that is called turgor pressure. The pressure exerted by the protoplasts due to entry of water against the rigid walls is called pressure potential ψ_p . Because of the rigidity of the cell wall, the cell does not rupture. This turgor pressure is ultimately responsible for – enlargement and extension of cells.

8.How is the mycorrhizal association helpful in absorption of water and minerals in plants?

Soln. Some plants have additional structures associated with them that help in water (and mineral) absorption. A mycorrhiza is a symbiotic association of a,fungus with a root system. The fungal filaments form a network around the young root or they penetrate the root cells. The hyphae have a very large surface area that absorb mineral ions and water from the soil from a much larger volume of soil that perhaps a root cannot do. The fungus provides minerals and water to the roots, in turn the roots provide sugars and N-containing compounds to the mycorrhizae. Some plants have an obligate association with the mycorrhizae. For example Pinus seeds cannot germinate and establish without the presence of mycorrhizae.

9.What role does root pressure play in water movement in plants?

Soln. As various ions from the soil are actively transported into the vascular tissues of the roots, water follows (its potential gradient) and increases the pressure inside the xylem. This positive pressure is called root pressure, and can be responsible for pushing up water to small heights in the stem. Root pressure can, at. best, only provide a modest push in the overall process of water transport. They obviously do not play a major role in water movement up tall trees. The greatest contribution of root pressure may be to re-establish the continuous chains of water molecules in the xylem which often break under the enormous tensions created by transpiration.

10.Describe transpiration pull model of water transport in plants. What are the factors influencing transpiration? How is it useful to plants?

Soln. Transpiration pull or cohesion-tension theory was originally proposed by Dixon and Joly in 1894 and further improved by Dixon in 1914. According to this theory, a continuous
column of water is present in the xylem channels of plant. The continuity of water column is maintained in the plant because of cohesive force of water molecules. There is another force of adhesion which holds water tp the walls of xylem vessels. During transpiration in plants, water is lost, in form of water vapour, from the mesophyll cells to exterior, through stomata. As a result, the turgor pressure of these cells decreases and the diffusion pressure deficit (DPD) increases. Now these cells take water from adjoining cells and the turgor of those adjoining cells decreases. This process is repeated and ultimately water is absorbed from nearest xylem vessels of leaf. As there is a continuous water column inside the xylem elements, a tension or pull is transmitted down and finally transmitted to root, resulting in the upward movement of water.

Factors affecting transpiration include both environmental and internal factors.

Environmental factors:

(i) Relative humidity – The rate of transpiration is inversely proportional to the relative humidity, i.e., the rate of transpiration is higher when the relative humidity is lower and lower when the relative humidity is higher.

(ii)Atmospheric temperature – A high temperature opens stomata even in darkness. Besides producing a heating effect, it lowers the relative humidity of the air and increases vapour pressure inside transpiring organ. Consequently, rate of transpiration increases.

(iii)Light – Because most of the transpiration occurs through stomata, the rate of transpiration is quite high is light. It falls down appreciably in the darkness.

(iv)Air movements – Transpiration is lower in the still air because water vapours accumulate around the transpiring organs and reduce the DPD of the air. The movement of the air increases the rate of transpiration by removing the saturated air around the leaves.

(v) Atmospheric pressure – Low atmospheric pressure enhances evaporation, produces air currents and increases the rate of transpiration.

(vi)Availability of water – The rate of transpiration depends upon the rate of absorption of soil water by roots. This is further influenced by a number of soil factors like soil water, soil particles, soil temperature, soil air, etc.

Internal or plant factors :

(i) Leaf area (transpiring area) – A plant with large leaf area will show more

transpiration than another plant with less leaf area.
(ii)Leaf structure – Leaf structure affects transpiration in following ways:
(a) Cuticular transpiration decreases with the thickness of cuticle and cutinisation of epidermal walls.
(b) Because most of the transpiration takes place through the stomata, their number and position influences the rate of transpiration.
(c) The sunken stomata are device to reduce the rate of transpiration by providing an area where little air movement occurs.
(iii)Root/shoot ratio – A low root/shoot ratio decreases the rate of transpiration while a high ratio increases the rate of transpiration.
(iv)Mucilage and solutes – They decrease the rate of transpiration by holding water tenaciously.
Transpiration is useful to plants in the following ways:
(i) Removal of excess water – It has been held that plants absorb far more amount of water than is actually required by them. Transpiration, therefore, removes the excess of water.
(ii)Root system – Transpiration helps in better development of root system which is required for support and absorption of mineral salts.
(iii)Quality of fruits – The ash and sugar content of the fruit increases with the increase in transpiration.
(iv)Temperature maintenance – Transpiration prevents overheating of leaves. However, plants growing in areas where transpiration is meagre do not show over¬heating. Some succulents can endure a temperature of 60°C without any apparent damage.
(v)Pole in ascent of sap and turgidity – Ascent of sap mostly occurs due to transpiration pull exerted by transpiration of water. This pull is important in the absorption of water. Further, transpiration maintains the shape and structure of plant parts by keeping cells turgid.
(vi)Distribution of mineral salts- Mineral are mostly distributed by rising column of sap.
(vii)Photosynthesis – Transpiration supplies water for photosynthesis.

11.Discuss the factors responsible for ascent of xylem sap in plants.
Soln. Xylem sap ascends mainly due to forces generating in the foliage of plants as a result of active transpiration. Thus, the factors which enhance the rate of transpiration are also the factors responsible for ascent of xylem sap in plants.
Various factors responsible for ascent of xylem sap in plants are as follows:
(i) Capillarity: There is limited rise of water in narrow tubes or capillaries due to

forces of cohesion amongst molecules of water and their property of adhesion to other substance.
(ii)Root pressure: It is positive pressure that pushes sap from below due to active absorption by root.
(iii)Transpiration pull: Transpiration in aerial parts brings the xylem sap under negative pressure or tension due to continuous withdrawal of water by them. Water column does not break due to its high tensile strength related to high force of cohesion and adhesion.

12.What essential role does the root endodermis play during mineral absorption in plants?

Soln. Like all cells, the endodermal cells have many transport proteins embedded in their plasma membrane; they let some solutes cross the membrane, but not others. Transport proteins of endodermal cells are control points, where a plant adjusts the quantity and types of solutes that reach the xylem. Because of the layer of suberin, the root endodermis has the ability to actively transport ions in one direction only.

13.Explain why xylem transport is unidirectional and phloem transport bidirectional.

Soln. Transport over longer distances proceeds through the vascular system (the xylem and the phloem) and is called translocation. In rooted plants, transport in xylem (to water and minerals) is essentially unidirectional, from roots to the stems. Organic and mineral nutrients however, undergo multidirectional transport. Food, primarily sucrose, is transported by the vascular tissue, phloem, from a source to a sink. Usually the source is part of the plant which synthesises the food, i.e., the leaf, and sink, the part that needs or stores the food. But, the source and sink may be reversed depending on the season, or the plant's needs. Since the source-sink relationship is variable, the direction of movement in the phloem can be upward or downward, i.e., bi-directional. Hence, unlike one-way flow of water in xylem, food in phloem tissues can be transported in any required direction.

14.Explain pressure flow hypothesis of translocation of sugars in plants.

Soln. The accepted mechanism used for the translocation of sugars from source to sink is called the pressure flow hypothesis. As glucose is prepared at the source i.e., in leaves, (by photosynthesis) it is converted to sucrose (a dissacharide). The sugar is then moved in the form of sucrose into adjacent companion cells and then into the living phloem i.e., in sieve tube cells by active transport. This process of

loading at the source produces a hypertonic conditions in the phloem. Water in the adjacent xylem moves into the phloem by osmosis. As osmotic pressure builds up, the phloem sap will move to areas of lower pressure. At the sink, osmotic pressure must be reduced. Again active transport is necessary to move the sucrose out of the
phloem sap and into the cells which will use the sugar converting it into energy, starch, or cellulose. As sugars are removed, the osmotic pressure of the phloem decreases and water moves out of the phloem

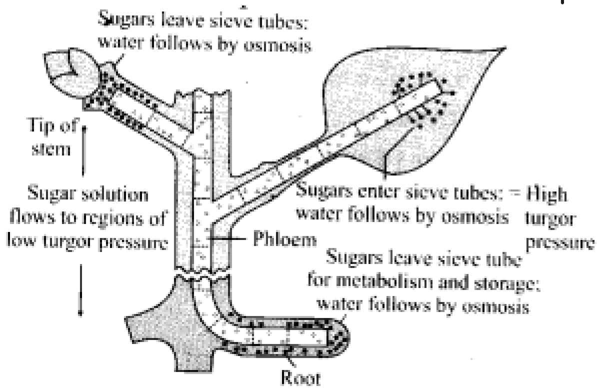


Fig.: Diagramatic representation of mechanism of translocation.

15.What causes the opening and closing of guard cells of stomata during transpiration?

Soln. Transpiration is the evaporative loss of water by plants. It occurs mainly through the stomata in the leaves. The immediate cause of the opening or closing of the stomata is change in the turgidity of the guard cells. The inner wall of each of the guard cells, towards the pore or stomatal aperture, is thick and elastic. When turgidity increases within the two guard cells flanking each stomatal aperture or pore, the thin outer walls bulge out and force the inner walls into a crescent shape and thus the stomata opens. The opening of the stoma is also aided due to the orientation of the microfibrils in the cell walls of the guard cells. Cellulose microfibrils are oriented radially rather than longitudinally making it easier for the stoma to open. When the guard cells lose turgor, due to water loss (or water stress) the elastic inner walls regain their original shape, the guard cells become flaccid and the stoma closes.

16.Differentiate between the following:
(a) Diffusion and Osmosis
(b) Transpiration and Evaporation
(c) Osmotic Pressure and Osmotic Potential
(d) Imbibition and Diffusion

(e) Apoplast and Symplast pathway of movement of water in plants
(f) Gutta'tion and Transpiration

Soln.

(a) Differences between diffusion and osmosis are as follows :

	Diffusion	Osmosis
(i)	It is the movement of all type of substances from the area of their higher free energy to the area of their lower free energy.	It is the movement of only solvent or water from its higher free energy or chemical potential to the area of its lower chemical potential when the solute particles are not allowed to diffuse.
(ii)	Diffusion can operate in any medium.	Osmosis operates only in a liquid medium.
(iii)	Diffusion is applicable to all types of substances – solids, liquids or gases.	It is applicable to only solvent part of a solution.
(iv)	It does not require any semipermeable membrane.	A semipermeable membrane is a must for the operation of osmosis.

(v)	It is purely dependent upon the free energy of the diffusing substance.	Osmosis is dependent upon the degree of reduction of free energy of one solvent over that of another.
(vi)	It helps in equalising the concentration of the diffusing substance throughout the available space.	It does not equalise the concentration of solvent on the two sides of the system.
(vii)	Hydrostatic or turgor pressure does not normally operate in diffusion.	Osmosis is opposed by turgor or hydrostatic pressure of the system.

(viii)	It is not influenced by solute potential.	Osmosis is dependent upon solute potential.
(ix)	Diffusion of a substance is mostly independent of the presence of other substances.	Osmosis is dependent upon the number of particles of other substances dissolved in liquid.

(b) Differences between transpiration and evaporation are as follows:

	Transpiration	**Evaporation**
(i)	It is a physiological process and occurs in plants.	It is a physical process and occurs on any free surface.
(ii)	The water moves through the epidermis with its cuticle or through the stomata.	Any liquid can evaporate. The living epidermis and stomata are not involved.
(iii)	Living cells are involved.	It can occur from both living and non-living surfaces.
(iv)	Various forces such as vapour pressure, osmotic pressure, etc. are involved.	Not much forces are involved.
(v)	Formation of vapours continues for some time even after the saturation of outside air.	Evaporation stops when the air is fully saturated.

(vi)	The rate of transpiration is slightly lower than evaporation under the influence of wind velocity because it lowers the leaf temperature.	It varies directly according to the velocity of wind.
(vii)	It is largely dependent upon absorption of water from the soil.	It continues as long as water is available on the surface.
(viii)	Water vapours are formed mostly in internal tissues of the plant.	Water vapours are formed at the free surface of water

(c)Differences between osmotic pressure and osmotic potential are as follows:

	Osmotic pressure	Osmotic potential
(i)	It is the pressure which develops in an osmotic system due to entry of water into it.	It is lowering of free energy of water in a system due to the presence of solute particles.
(ii)	It develops only in a confined system.	Osmotic potential is present whether the solution occurs in a confined system or an open system.
(iii)	The value is positive though numerically equal to osmotic potential.	The value is negative though it is numerically equal to osmotic pressure.

(d) Differences between imbibition and diffusion are as follows:

	Imbibition	Diffusion
(i)	It involves the absorption of solvent or water by a solid substance (adsorption occurs).	It is the movement of all types of substances from the area of their higher free energy to the area of their lower free energy.
(ii)	It produces heat.	It does not produce heat.
(iii)	It can develop a very high pressure (upto 100 atm) called imbibition pressure.	It cannot develop a high pressure.

(e) Differences between apoplast pathway and symplast pathway are as follows:

	Apoplast pathway	Symplast pathway
(i)	It consists of non-living parts of plant body, *i.e.*, cell walls and intercellular spaces.	It consists of living parts of plant body, *i.e.*, protoplasts connected by plasmodesmata.
(ii)	There is little resistance in the movement of water.	Some resistance occurs in the movement of water through symplast.
(iii)	It is faster.	It is slightly slower.
(iv)	Metabolic state of root does not affect apoplast pathway.	Metabolic state of root directly affects symplast pathway.

(f) Differences between guttation and transpiration are as follows:

	Guttation	Transpiration
(i)	Guttation is the loss of liquid droplets from the plant.	It is the loss of water by a plant in the form of vapours.
(ii)	Guttated water is a dilute solution of both inorganic and organic substances.	The transpired water is pure water.
(iii)	Guttation commonly occurs at the margins and the tips of the leaves.	Transpiration occurs through the general surface of the leaves and the young stems.
(iv)	Guttation mostly occurs during night and early hours of the morning.	Most of the transpiration occurs during the hotter periods of the day. It is negligible during night.
(v)	Guttation occurs through water pores called hydathodes.	Transpiration occurs through stomata, lenticels and epidermal cells.
(vi)	The water pore is always kept open.	Stomata can be opened or closed.
(vii)	Guttation does not occur under condition of water deficiency.	Transpiration continues even when the plant is under water stress.
(viii)	Excessive guttation does not cause loss of turgidity.	Excessive transpiration produces wilting.

Mineral Nutrition Class 5 Notes Biology Chapter 12

Topic 1 Minerals and Their Importance

Living organisms require a number of macromolecules, such as carbohydrates, proteins, fats, water and minerals in order to grow and develop.
Thus, the inorganic substances or minerals that provide nourishment to the living organisms or wftrk as a raw material for body building and maintaining its normal functions are termed as mineral nutrients and the mode of taking all required nutrients is called mineral nutrition. Nutrients are basically divided into two main types
(i) Organic nutrients
(ii) Inorganic nutrients The product of photosynthesis (various sugars) are considered as organic nutrients, while, those absorbed by the roots via various methods are known as inorganic nutrients.
In this chapter we will concentrate mainly on inorganic nutrients.
Methods to Study the Mineral Requirements of Plants
Mineral requirements of plants was determined by the culture experiment, developed by a prominent German botanist Julius Von Sachs (1860) for the first time.

Hydroponics or Soilless Culture
This technique was demonstrated from Julius Von Sach's experiments that plants could be grown to their maturity in a well defined nutrient solution even in the absence of soil. This technique of growing plant in a nutrient solution without soil is well known and is also known as water culture.
The methods involved in hydroponics require a very careful purification of water

and nutrient salts. This is essential in order to assess the role of a particular mineral.

Hydroponic Setup

(a) In hydroponic plant production, plants are grown in a tube or trough that are placed in slightly inclined position.
(b) A pump is used to circulate the nutrient solution from the reservoir to the elevated (upper) end of the tube.
(c) Funnel is used for adding solution (water and nutrients).
(d) Bent tube is used for aeration.
The nutrient solution flows down due to gravity and returns to the reservoir of the hydroponic setup. In this way, roots are bathed in aerated nutrient solution continuously.

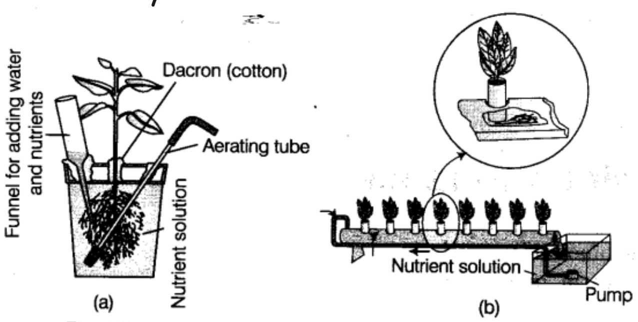


Fig. 12.1 (a) A typical set-up for nutrient solution culture
(b) Hydroponic plant production (set-up)

On conducting a series of experiments, in which roots of the plants were immersed in nutrient solution by eliminating or adding an element in varied concentration. From this, mineral nutrition suitable for the growth of the plant was obtained.

Result Hydroponic revealed the identification of essential elements for plant growth and also helps in discovering their deficiency symptoms.

Conditions Necessary in Hydroponics to Achieve Optimum Growth

(a) The concentration of mineral nutrients must be constantly maintained.
(b) The solution must be aerated adequately for proper growth and activities of roots.
(c) pH of the solution is checked from time to time and corrections are made if necessary.

Uses of Hydroponics

(a) This technique has been successfully employed for commercial production of vegetables (like tomato, seedless cucumber, lettuce, etc) and also in knowing the

toxicity of plant (if element is present in high amount).
(b) Useful in determining the essential role of nutrients or mineral elements for the metabolism of plant.

Essential Mineral Nutrients (Elements)
Essential elements are those which have structural or physiological role and without which plants are unable to complete their life cycle.
Plants can absorb most of the minerals present in the soil. More than sixty minerals present in soil have been recorded essential in plants out of 105 discovered so far.

Apart from all these elements some plants accumulate other elements also, that are heavy and toxic in nature such as silicon, cobalt, selenium and gold. Some other plants growing near nuclear test sites also accumulate radioactive elements like strontium.

However, techniques had developed in order to detect the mineral even at very low concentration,
i. e., 10 g/mL. Thus, all the elements found in plants are not essential for plant growth and development.

Criteria for Essentiality
In order.to determine whether the particular element is essential or non-essential, the element must follow the criteria for essentiality given below
(i) The element must be able to support normal growth and reproduction, i.e., in the absence of a particular element, the plant becomes unable to complete its normal life cycle.

(ii) Requirement of the particular element in appropriate amount must be specific and it should not be replaced by any other element, i.e., if the deficiency of one element occurs, it should not be fulfilled by the addition of some other element.

(iii) The element must be involved directly in the functioning and metabolism of the plant.

Classification of Essential Mineral Elements
Essential elements occur in different proportions in plants. On the basis of the

above mentioned criteria of essentiality some elements have been found to be absolutely essential for the normal and better growth, metabolism and development of plants.

These elements have been grouped into following two categories based on quantitative requirements

i. Macronutrients

These are the elements generally found in plant tissues in large amounts (in excess of around 10 m mole kg-1 or 10 mg per gram of dry matter) and also called major elements. These elements are generally involved in the synthesis of organic molecules and development of osmotic potential.

These are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium and magnesium. Out of all these elements, carbon, hydrogen and oxygen are obtained from CO_2 and H_2O while, the others are obtained from the soil.

ii. Micronutrients

These are the elements generally found in traces (very small amount only, i.e., less than 10 m mol kg^{-1} or less than 0.1 mg per gram of dry matter). Micronutrients are generally eight in number and include iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel. These are mostly involved in the functioning of enzymes as co-factors or activators of metals.

Differences between Macronutrients and Micronutrients

Macronutrients	Micronutrients
Their quantities can be easily detected in plants as they occur in large amounts.	They occur in very small amounts in plants.
These are needed for growth, metabolism and other body functions.	These nutrients help in detoxifying the body and warding of harmful diseases.
Their required concentration is atleast 1 mg/g of dry matter.	Their required concentration is equal to or less than 0.1 mg/g of dry matter.
These have significant role in development of osmotic potential.	These do not have any role in osmotic potential.
Their higher concentration do not cause toxicity.	They cause toxicity even with slight increase from their maximal range.
Compounds of macronutrients contain calories.	Compounds of micronutrients do not contain calories.
e.g., Proteins, carbohydrates and fats.	e.g., Vitamins and minerals.

Based on the diverse functions of essential elements, these are also categorised into four other categories given below

(i) As the constituents of biomolecules These are the essential components of biomolecules. Hence, known as the structural elements of cells, e.g., carbon, hydrogen, oxygen and nitrogen.

(ii) As the energy related chemical compounds Some elements also function in providing energy to the cell, e.g., Phosphorus is a component of ATP which functions as an energy currency of all the living systems, while magnesium is a component of chlorophyll, which is involved in the conversion of light energy into chemical energy.

(iii) As the part of enzymes showing catalytic effects Many of the essential elements are required in the form of cofactors by enzymes. They function as the activator or inhibitor of enzymes, e.g., Mg^{2+} acts as an activator of several enzymes in both photosynthesis (e.g., Ribulose biphosphate (RuBP) carboxylase, phosphoenol pyruvate (PEP) carboxylase) and respiration (e.g., hexokinase and phosphoffuctokinase).
While Zn^{2+} acts as an activator of alcohol dehydrogenase and Mo of nitrogenase during the course of fixation of nitrogen.

(iv) As the elements altering osmotic potential Some of the essential elements also alter the osmotic potential. Most of the osmotic potential of cell is due to the inorganic salts.
Osmotic potential is necessary for absorption of water and maintaining turgidity of cell.

Role of Macro and Micronutrients
The essential elements perform several important rot, most important of them are given below
1. Regulation of permeability of cell membrane.
2. Maintenance of osmotic potential of cell sap.
3. Some of them takes part in an electron transport system.
4. Others function in buffering action, enzymatic activity and also function as a major constituent of macromolecules and co-enzymes.

Macronutrients

Various macronutrients with their sources, regions and numerous junctions are given below
i. Nitrogen (N)
It is a major constituent of amino acids, proteins, nucleic acids, hormones, vitamins, etc. It was the first macronutrient to be discovered and is required in very large amount by plants.
Nitrogen is not utilised by plants directly as such. It is mainly absorbed in the form of nitrates (NO_3), while others absorb, it in the form of nitrites (NO_2) or as ammonium ion (NH_4^-)

Region It is usually required by all parts of plants, mainly the meristematic tissues, and by all the cells, which are metabolically active in nature
Functions Its main function is in growth, metabolic activities and also serves as enzymes in photosynthesis, etc.

Carbon, Hydrogen and Oxygen
These are although not considered as mineral elements still, they have an essential role in growth of plants. Together they constitute about 94% of the total dry weight of the plant. All of these are also important part of carbohydrates, fats and proteins.

C, H, O and N are all together called structural elements because they are the components of biomolecules of the cell.

ii. Phosphorus (P)

Most soils are phosphorus deficient. It is present in plants as both organic and inorganic forms. Organic form of phosphorus is not absorbed by plant as such, instead, it is either taken from the solid or the solution phase of soil. It is a constituent of certain proteins, all nucleic acid and cell membranes.
The decomposition organic form results into an inorganic form of phosphorus, which is then utilised by the plants.
It is generally absorbed by roots from soil in the form of phosphate ions (either as $H2PO_4^-$ or HPO_4^{2-}).

Region It is required in all meristems or young tissues and in the regions of developing fruits and seeds.
It generally gets withdrawn from the older tissues which becomes metabolically less active.
Functions It is mainly involved in phosphorylation reactions and also has its importance in energy transfer reactions.
Phosphorus is also present in high energy biomolecules such as adenosine triphosphate (ATP) and guanosine triphosphate (GTP). It also has its major role in ripening of grains and fruits.

iii. Potassium (K)

It does not acts as a constituent of any organic substance, so potassium (K^+) is available to plants in its inorganic form such as potassium sulphate, potassium nitrate, etc. It is one of the major constituents of protoplasm.
Region It is found in all tissues of plants that has the property of differentiating themselves like meristematic tissues, bud, leaves and root tips.

Its amount is equal in whole plant except in seeds where it is found in lesser quantity.
Functions It helps in maintaining anion-cation balance in cells and is also involved in the synthesis of proteins. It has its major role in opening and closing of stomata, in activation of enzymes and also helps in maintaining the turgidity of cells.

iv. Calcium (Ca)

It is an element which is always found in green plants and is absorbed by them in the form of calcium ions (Ca^{2+}) from the soil.
Region It is needed much in differentiating and meristematic tissues. It gets accumulated mosdy in the older leaves.
Functions It functions in the synthesis of pectin (calcium pectate) found in middle lamella of the cell wall during cell division. It is also involved in the organisation of mitotic spindle. It activates certain enzymes and plays an important role in the regulation of cellular activities.

v. Magnesium (Mg)

It is the major component of ring structure of chlorophyll, without which the formation of chlorophyll does not takes place. It is absorbed by the plants in the form of a divalent magnesium ion (Mg^{2+}) from the soil.
During rainy season magnesium is leached out from the soil due to which its amount become deficient in plants.
Region It is required in growing areas of roots, stems, seeds.

Functions It helps in the activation of enzymes of photosynthesis and respiration, in the formation of chlorophylls, carotenoids and nucleic acids (DNA and RNA) and to maintain the structure of ribosome.

vi. Sulphur (S)

It is found usually in the complex proteins of plants.
The most abundant reservoir of sulphur in soil is in the organic form, such as lipids, amino acids, proteins, etc.
It is absorbed by the plants in the form of sulphate ions (SO_4^{2-}) from mineral fraction of soil.

Region It is required mostly in young leaves and meristems.

Functions It acts as a major constituent in amino acids like cysteine and methionine and. also of several co-enzymes, vitamin (like thiamin, biotin, coenzyme-A (Co-A) and ferredoxin).

It is due to the presence of sulphur constituent in Liliaceae family plants like onion, garlic, etc., that they have a characteristic odour.

Micronutrients

Various micronutrients with their sources, regions and numerous functions are given befow

i. Iron (Fe)

It is required in huge amount by plants in comparison to other micronutrients. It occurs in the soil mainly in the form of hydroxides and oxides and is absorbed in the form of ferric ions (Fe^{3+}).

Region It is required by every part of plant but is found abundantly along veins of the leaves.

* Excess amount of iron is stored as ferritin in plants.

Functions It is involved in the transfer of electrons like ferredoxin and cytochromes. Also plays an important role in reactions involving conversion of energy in both photosynthesis and respiration.

i. e., $Fe^{2+} \rightarrow Fe^{3+}$ helps in the development of chloroplasts, chlorophyll and other pigments.

a. Manganese (Mn)

The oxides of manganese are common in soil. However, its highly oxidised form is not available to plants.

It is absorbed by the plants in the form of manganous ions (Mn^{2+}).

Region It is required in leayes and seeds of plant.

Functions It is helpful is activating many enzymes that are involved in photosynthesis, respiration and nitrogen metabolism. It also functions majorly in photolysis of water in order to liberate oxygen during the process of photosynthesis.

iii. Zinc (Zn)

Zinc is absorbed in the form of Zn^{2+}ions. Zinc occurs in ferromagnesium minerals. These minerals are weathered in order to liberate bivalent form of Zn^{2+} .

It is considered to be more soluble in soil than other heavy metals.

Region Zinc is required in every part of the plant. Functions It helps in activation of various enzymes like carboxylases, oxidases, dehydrogenases, kinases, etc., and also in the formation of chlorophyll pigment. It is also needed in the synthesis of auxin.

iv. Copper (Cu)

It is found in very low amount in soils. It is absorbed as cupric ions (Cu^{2+}). It acts as a component or activator of plastocyanin, cytochrome oxidase and many other enzymes.
Region It is also required in every part of plants like zinc.
Functions Like iron, it is also involved with enzymes that are required in redox reactions.
It can also oxidise in the reversible direction, i.e., from Cu to Cu_2:

v. Boron (B)

It is one of the most essential element for the growth of nearly all plants, e.g., Tomafo, lemon, mustard, cotton, etc.
It is absorbed by the plants in the form of BO_3^{3-} or $B_4O_7^{2-}$ ions from the soil.
Region It is required mostly by leaves and seeds.
Functions It is essential in transportation of carbohydrate through phloem tissues. Boron is needed for uptake and utilisation of calcium, in the germination of pollen and root nodulation elongation of cell differentiation and carbohydrate translocation.
If pH increases, availability of boron to plant gets decreases.

vi. Molybdenum (Mo)

The amount of this element in soil vary widely. Plants obtain it in the form of molybdate ions (MoO_2^{+}).
Region It is required everywhere in plants but mostly utilised by roots.
Functions It is an essential component of several enzymes including two enzymes involved in metabolism of nitrogen, i.e., nitrogenase and nitrate reductase. It also has role in reduction of nitrate to nitrite during the synthesis of amino acids.

vii. Chlorine (Cl)

It is abundant in nature. It is absorbed by the plants in the form of chloride ions (Cl).
Region It is also required everywhere like zinc and copper. Functions It helps in transfer of electrons from H_2O to photosystem-II in photosynthesis (water splitting reaction in order to evolve O_2). It is also helpful in determining the concentration of solute with Na^+ and K^+. It seems to be essential in balancing cationic and anionic ratio in cells.
Nickel (A micronutrient)

It is also added as a micronutrient recently. It is found to be very mobile in plants and is absorbed by the plant in the form of Ni_2^+ ions.

Region It is required in whole plant.
Function It acts as an essential part of enzyme urease which hydrolyse urea—> CO_2 + NH_4.
Deficiency symptoms Plant produces non-viable seeds upto 3rd generation due to its absence and may also leads to necrotic spots on leaf tips.

Deficiency Symptoms of Essential Elements
The deficiency symptoms vary from element to element and they tend to disappear when the particular deficient mineral nutrient is provided to the plant.

Whenever the supply of an essential element becomes limited, growth of the plant gets retarded.
However, if the deprivation of the same nutrient continue for a long period of time, it may eventually leads to the death of the plant.
(i) Critical Concentration is limited concentration of the essential element below which the growth of plant get reduced, retarded or stops.

Each essential element plays a vital role in structural and functional composition of plant. Thus, in the absence of any particular element, plants shows various morphologicial changes, which are indicative of certain element deficiencies and are called deficiency symptoms.
The plant parts show symptoms of deficiency depending on the mobility of that element in the plant.

Accordingly, these can also be divided as
(i) Mobile elements When the elements are actively mobile within the plants, the symptoms tend to appear first in older leaves and tissues. It is because the elements get mobilised from senescing regions to young tissues.
For example, deficiency symptoms of N, K and Mg are visible in the senescent leaves first because these elements are actively mobile.

In the older leaves, biomolecules containing these elements are broken down, making these elements available for mobilising to younger leaves.

(ii) Immobile elements When the elements are immobile within the plants, the symptoms appear first in young leaves and tissues, because the elements are not transported out of the mature organs.
For example, Elements like sulphur and calcium are not released out easily from the plant as they act as an important part of the structural component of the cell.
This aspect (mobility of elements) of mineral nutrition in plants play a very vital role in agriculture and horticulture.

Some Major Deficiencies in Plants
Various kinds of deficiency symptoms shown by the plants are given below
(i) Necrosis It is the phenomenon, which leads to the death of tissues, cell or organ mainly leaf tissue, while it is still a part of the living plant.
It is caused due to the deficiency of elements like Ca, Mg, Cu, K, etc.
(ii) Chlorosis It is the loss of chlorophyll which leads to the yellowing of leaves.
This symptom is caused by the deficiency of elements like N, K, Mg, S, Fe, Mn, Zn and Mo in plants.
(iii) Inhibition of cell division It occurs due to the lack or low levels of elements like N, S, Mo, K, etc.
(iv) Delay flowering Deficiency of elements, like N, S, Mo leads to delay in flowering of plants.
(v) Stunted plant growth If the low availability of element occurs, it may leads to inhibition of growth in plant and may eventually lead to the dwarfing (shortening) of whole plant, e.g.y N, K, Ca, S, Zn, B, Mo and Cl.
(vi) Premature fall of leaves and buds It is another type of deficiency symptom that occurs due to the lack of different minerals like P, Mg, Cu, etc.
Differences between Necrosis and Chlorosis Necrosis Chlorosis

Necrosis	Chlorosis
The death of a cell or group of cells, while it is still a part of the living plant is known as necrosis.	The yellowing of leaves due to reduction of chlorophyll content is known as chlorosis.
It is caused due to the deficiency of copper, calcium and chlorine.	It is caused by the deficiency of magnesium, sulphur, iron, manganese and nitrogen.
It results in appearance of brown spots.	It results in appearance of yellow spots.
Brown colour spot does not give mosaic pattern.	Yellow appearance of spots give mosaic pattern.

Toxicity of Micronutrients
A moderate decrease of micronutrients cause deficiency symptoms, while a moderate increase leads to toxicity. Thus, whenever the concentration of mineral ion in tissues reduces the dry weight by about 10%, it is considered to be toxic.

The level of toxicity varies for different micronutrients from plant to plant. When the toxicity of element increases to certain level it may also inhibit the uptake of another element. e.g., the prominent symptom of manganese toxicity is the appearance of brown spots surrounded by chlorotic veins.

It is important to know that manganese competes with iron and magnesium for uptake and with magnesium for binding with enzymes. Mangaqcse also plays role to inhibit the calcium translocation in shoot apex.
Therefore, presence of manganese in excess amount may, induce deficiencies of iron, magnesium and calcium.

Topic 2 Mechanism of Absorption and Nitrogen Metabolism

Mineral Absorption
Absorption of mineral salts by plants from the soil occurs through the roots mainly from the root hairs and the zones of absorption. Hence, plants absorb the minerals from the soil for their translocation to other parts of the body through stream of xylem.

Minerals are not absorbed as such by the plants instead they are absorbed in their ionic forms.
For example, chlorine is not absorbed as such by the plant insteadly it gets accumulated in the form of chloride ions.

Mineral absorption by plants is done by two different phases
(i) Initial Phase (Passive transport) It is the pathway by which water or ions present in the free space or outer space of cells are up taken by roots of plants by taking apoplast pathway (avoid entry into cellular membranes and cytoplasm).

In this phase, the plant absorbs mineral very rapidly and does not need any metabolic energy in the form of ATP. Thus, it is called passive process. The passive movement of ions occurt through ion-channels and the transmembrane proteins that functions as selective pores into apoplast.

(ii) Metabolic Phase (Active transport) It is the pathway which is dependent on metabolic energy in the form of ATP for the uptake of mineral ions by the roots into the inner spaces i.e., symplast of the cell. Hence, is called active process.

The movement of ions from cell-to-cell is called flux. It can be further divided into two main types
(i) Influx (inward movement of ions into the cells)
(ii) Efflux (outward movement of ions out of the cells)

Differences between Active and Passive Absorption

Active Absorption	Passive Absorption
It involves expenditure of energy.	It does not involve expenditure of energy.
The movement of molecules or ions takes place against a concentration gradient.	The movement of molecules takes place along the concentration gradient.
The movement is usually unidirectional.	The movement is reversible.
It results in the accumulation of ions.	It results in an equilibrium of the molecules on both sides of a membrane.

Translocation of Solutes

After absorption the mineral salts passes readily inward with the transport of water. The translocation of mineral elements to different parts of the body is done through tracheary elements of the xylem to reach upwardly to the leaves and other parts (ascent of sap). It is done through the plants by the transpirational pull.

Note:

- The upward movement of water through stem is called ascent of sap. It occurs mainly through xylem.
- Minerals pass through xylem (not phloem) is proved by Stout and Hoaglan in 1939.

Soil as Reservoir of Essential Elements

Soil itself acts as a mineral nutrient reservoir in natural conditions, but it is not essential for the growth of plant. The majority of nutrients studied as far are essential for the growth and development of plants. These elements become available to the roots of plants by the weathering and breakdown of rocks.
Due to which the soil become enriched with ions and inorganic salts which are ultimately taken up by the plants itself.

Functions of Soil

Following functions are being performed by the soil

(i) Soil supplies minerals to plant and also harbours nitrogen fixing bacteria and other microbes.

(ii) It contains wide variety of substances essential for plant.

(iii) It holds water and supplies air to the roots.

(iv) It also acts as a matrix that helps in stabilisation of plant.

Fertilisers, are the organic or inorganic materials that are added to soil to supply one or more nutrients which are essential to the growth of plants. Since, deficiency of essential mineral affects yields of crop thus, both macro (N, P, K, S, etc) and micronutrients (Cu, Fe, Zn, Ni, M, B, -etc) acts as component of fertiliser and applied as per requirement.

Metabolism of Nitrogen

Nitrogen exists as two nitrogen atoms joined by a very strong triple covalent bond (=)Nitrogen is
needed by plants for the production of proteins, nucleic acids (DNA and RNA), chlorophyll and many other vitamins. It is also the most prevelant element apart from carbon, hydrogen and oxygen.

It is absorbed as an inorganic compound which is changed into its organic form by plants and certain microbes.

The ultimate source of nitrogen is the nitrogen gas present in the atmosphere. As nitrogen is limited in nature, plants compete with microbes for available nitrogen in the soil. Thus, nitrogen acts as a limiting nutrient for both natural and agricultural ecosystems.

Nitrogen Cycle

It is the process of cycle of events by which free atmospheric nitrogen is converted into its various chemical forms.

The nitrogen cycle consists of four important processes, i.e., nitrogen-fixation, ammonification, nitrification and denitrification.

1. Nitrogen-Fixation

In this process, atmospheric nitrogen is fixed which is to be used by the plants. In this step, the molecular nitrogen .

2. converted into inorganic nitrogenous compounds like nitrate, nitrite and ammonia.

Nitrogen fixation is of two types

(i) Physical nitrogen-fixation

(ii) Biological nitrogen-fixation

i. Physical Nitrogen-Fixation

It is the conversion of N_2 to inorganic nitrogenous compounds without the involvement of microorganisms.

Fixation occurs in nature by lightening and ultra violet radiations by which nitrogen gets converted into its oxides (as NO, NO_2, N_2O etc) on combining with O_2. These oxides also gets generated by forest fires, industrial combustions and by. some power generating stations.

$$2N_2 + O_2^- \xrightarrow[\text{discharge}]{\text{Electric}} 2NO_3^-$$

$$2NH_3 + 3O_2 \longrightarrow 2NO_2^- + 2H^+ + 2H_2O$$

ii. Biological Nitrogen-Fixation

The conversion of atmospheric nitrogen into inorganic nitrogenous compounds (nitrate, nitrite and ammonia) through microorganisms (bacteria, cyanobacteria, etc) are called biological nitrogen-fixation.

As only few organisms utilise atmospheric nirogen, certain prokaryotes are capable of fixing nitrogen. The prokaryotic organism that reduce nitrogen has an enzyme called nitrogenase such microbes are called 2 fixers.

NEN Nitrogenas

The organisms that fix nitrogen can be of two types

(a) Asymbiotic or Free living bacteria These are bacteria that are not present in close relationship with another bacteria or other organisms in order to convert nitrogen into ammonia, e.g., number of cyanobacteria like Anabeana and Nostoc.

The free living bacteria can also further divided as

- Free living aerobic These include microbes like Azotobacter and Beijemickia.
- Free living anaerobic These include microbes like Rhodospirillum and Clostridium.

(b) Symbiotic bacteria These are bacteria the fixes nitrogen by forming close associations with each other or with another organism, e.g., relationship between Rhizobium bacteria with legumes and
mycorrhizae with vascular plants, etc.

Frankia and Rhizobium, both are unable to fix nitrogen when present as free living (aerobes) in soil. But when present as symbionts they become anaerobes and are able to fix atmospheric nitrogen.

Symbiotic Biological Nitrogen-Fixation
The process of symbiosis involves two organisms living together in different associations. Several types of biological nitrogen fixing associations are known. The most familiar one is the relationship of Rhizobium with the roots of several legumes belonging to class-Leguminosae like sweet pea, lentils, garden pea, alfalfa, sweet clover, broad bean, clover beans, etc.
They get associated mosdy on the root hair cells, the root hair curl and the bacteria invade it. An infection thread is produced carrying the bacteria into the cortex where they initiate root nodule formation. Root nodules are small, irregular outgrowth on the roots.
They are internally pinkish in colour due to the presence of leguminous haemoglobin or leghaemoglobin (similar to the haemoglobin, the red pigment present in human blood).
Symbiotic nitrogen fixing bacteria are also known to occur in the roots of certain non-leguminous plants (both angiosperms and gymnosperms) i.e.,Alnus and Cycas respectively.

Insectivorous Plants
The carnivorous angiosperms (insectivorous plants) are autotrophic in nature. But, the strange thing about these plants is they behave as heterotrophic organisms for supplementing their nitrogen requirements by trapping insects and other small animals enzymatically and digesting them.
They usually grow in water logged soil or swamps where the soil is deficient in nitrogen supply. Thus, these plants fulfil their need from insects and small animals by trapping them through the leaves, e.g., Pitcher plant (Nepenthes), Venus fly trap, sundew, water flewtrap etc.

Nodule Formation

The process of formation of nodules is a series of multiple interactions that takes place between Rhizobium bacterium and the root system of legume plant (host). During the process, bacteria initially grow in soil near the roots of higher plants. They are unable to fix nitrogen there:, but after coming in contact with the roots of leguminous plants, they interact chemically and enter into roots through root hairs.

The process of nodule formation is as follows

(i) Rhizobium multiply and colonize itself to the surrounding of the roots of host plant where it gets physically attached to the epidermal root hair cells.
(ii) After attachment, the root hair gets curled up at the tip due to which bacteria invade the root hair.
(iii) The enzymes from the bacteria degrade the parts of root hair cell wall which produces a thread-like structure called infection thread.
(iv) The bacteria invade the infection thread and reaches upto the inner cortex of the root.
(v) The bacteria after reaching cortex (mainly tetraploid cells) stimulate the initiation of formation of nodule.
(vi) Bacteria enlarges in size and become bacteroid (rod-shaped) thus, leaving the infection thread and enter the cells, i.e., inner cortical and pericycle cells to divide.
(vii) This growth and division of pericycle and . cortical cells leads to the formation of a knob-like structure called mature root nodule.
(viii) The nodule, thus formed after division is finally responsible for the direct vascular connection with the host for the exchange of nutrients.

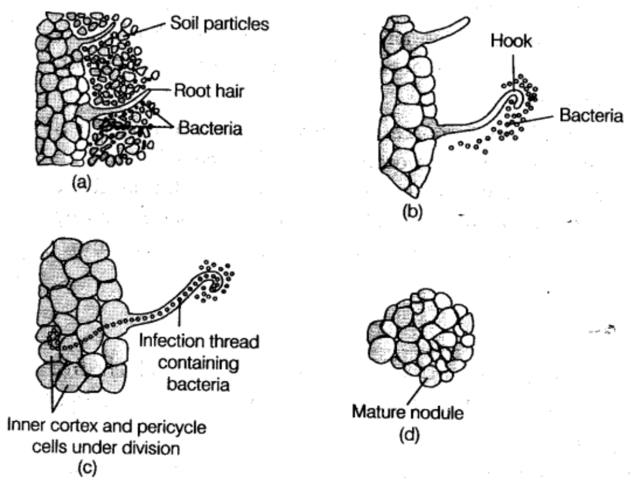


Fig. 12.2 Development of root nodules in soyabean
(a) Chemical recognition (b) Curling of root hair
(c) Formation of infection thread (d) Nodule formation

Mature Nodule

The mature nodule thus, formed after a series of events (as discussed above) and

chemical changes contains all the essential biochemical components i.e., leghaemoglobin and the enzyme nitrogenase. The enzyme nitrogenase catalyses the conversion of free nitrogen into ammonium, (first stable product).
The enzyme nitrogenase has two subunits, i.e., Fe protein (non-heme iron protein) and Mo-Fe protein (iron molybde-num protein).

The Fe protein component reacts with ATP and reduces Mo-Fe protein which then reduces 2 to ammonia.

$$N_2 + 8e^- + 8H^+ + 16\,ATP \xrightarrow{\text{Mo-Fe nitrogenase}} 2NH_3 + H_2 + 16\,ADP + 16\,Pi$$

Nitrogenase enzyme, cannot function in aerobic conditions as it is highly sensitive to molecular oxygen (O_2). Thus, for its activity it requires anaerobic conditions. Hence, in order to protect this enzyme from oxygen, the nodules produce a substance known as leg-haemoglobin (oxygen scavenger). Nitrogenase is not active when these microbes lives in aerobic conditions, i.e., free-living but becomes active or functional in anaerobic conditions during events of nitrogen fixation.

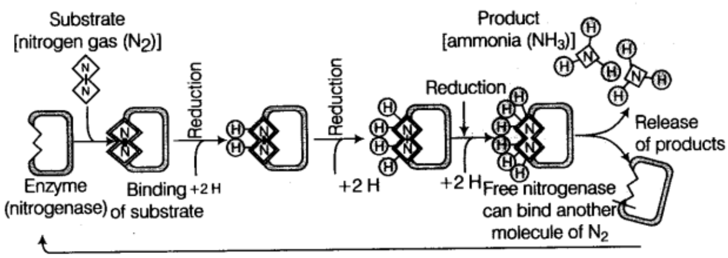


Fig. 12.3 Steps of conversion of atmospheric nitrogen to ammonia by nitrogenase enzyme complex found in nitrogen-fixing bacteria

Note:

- Winograd Sky (I89l) discovered biological nitrogen fixation.
- The reaction involving NH_3– synthesis by nitrogenase enzyme requires a very high input of energy (8 ATP for each NH_3 produced). The energy required, thus, is obtained from the respiration of the host cells.

2. Ammonification

In next step, organic matter (proteins and nucleic acids) of the dead remains are decomposed in order to produce ammonia (NH_3) by microorganisms (like Actinomycetes, Clostridium etc.). Out of the ammonia product, some of the ammonia gets volatilised and re-enters into the atmosphere, while most of it undergo the process of nitrification by soil bacteria.

Fate of Ammonia

Nitrogen assimilation results in the formation of ammonia which is further used for the synthesis of amino acid. Most of the plants can assimilate both nitrate and ammonium ions (NH_4) (the ammonium ions are formed by the protonation of ammonia at physiological pH). Ammonium ions are toxic to plants and cannot accumulate in them.

Thus, these 4 are used in the synthesis of amino acids in plants by following two methods

(i) Reductive animation During this process, the ammonia reacts with a-ketoglutaric acid (organic acid) and forms an amino acid, i.e., glutamic acid.

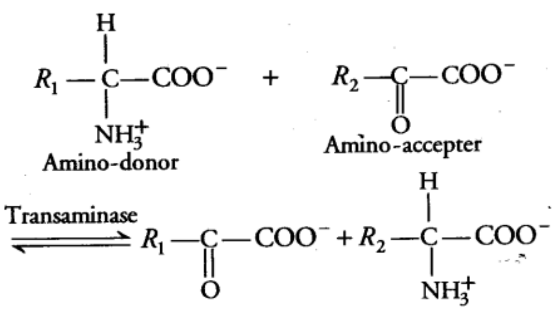
$$\xrightarrow[\text{dehydrogenase}]{\text{Glutamate}} \text{Glutamic acid} + H_2O + \text{NADP}$$

(from Krebs' cycle)

(ii) Transamination It is the transfer of amino group ($—NH_2$) of one amino acid to keto group ($C = O$) of another keto acid. The enzyme responsible for this is transaminase or aminotransferase.

Glutamic acid is the main amino acid involved in the synthesis of other amino acids through transamination.

Glutamic acid is mainly responsible for making the transfer of amino group to keto group possible.



Amides

These are generally formed by the combination of amino acids and ammonia. Their formation takes place by replacement of hydroxyl ions of amino acid by NH_2 ion.

The two most common amides formed in plants are aspargine and glutamine formed by the addition of another amino group to amino acids i. e., aspartic acid and glutamic acid respectively,

Uses of Amides

(i) Both of the amides, i.e., aspargine and glutamine acts as metabolic reservoirs.

They get accumulated in the tissue of healthy plants at the time of assimilation of ammonia (if assimilation occurs in excess amount).

(ii) They are translocated to other parts of plant through xylem vessels in the form of nitrogen rich compounds because they contain more nitrogen than the amino acids.

In some plants ureides acts as transporters of fixed nitrogen along with transpiration stream (e.g., soyabean). These also have high nitrogen to carbon ratio.

3. Nitrification

It is the process in which ammonia produced by the degradation of manures may not be available to plants. So, it is first oxidised to nitrite by the soil bacterium Nitrosomonas or Nitrococcus. This nitrite is then further oxidised to nitrate by another soil bacterium i.e., Nitrobacter. The bacteria which helps in the process of nitrification are collectively known as chemoautotrophs.

$$2NH_3 + 3O_2 \xrightleftharpoons{Nitrosomonas} \underset{\text{(Nitrite)}}{2NO_2^-} + 2H^+ + 2H_2O$$

$$2NO^-{}_2 + O_2 \xrightleftharpoons{Nitrobacter} \underset{\text{(Nitrate)}}{2NO_3^-}$$

The nitrate thus, formed are absorbed by plants and then transported to the leaves where it gets reduced to ammonia that finally forms amino-group of amino acids.

4. Denitrification

It is the process in which the nitrate present in the soil is reduced back to free nitrogen (N_2). The process of denitrification is carried out by denitrifying bacteria (like Thiobacillus denitrificans, Pseudomonas denitrificans etc).

Denitrifying bacteria utilises nitrate and nitrite ions as electron acceptors in place of oxygen.

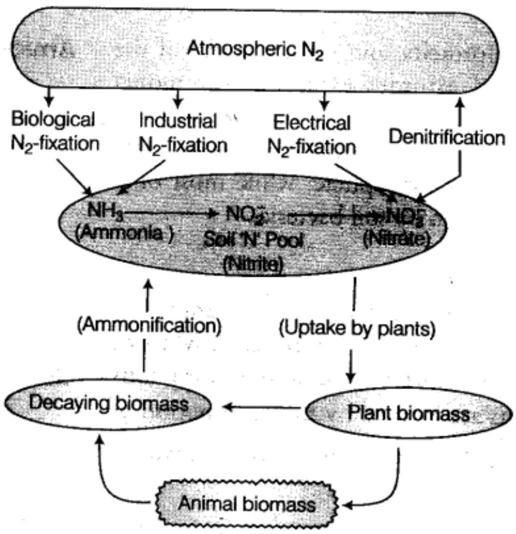


Fig. 12.4 The nitrogen cycle showing relationship between the three main nitrogen pools-atmospheric, soil and biomass

Mineral Nutrition Class 11 MCQs Questions with Answers

Question 1.

In plants, a common symptom caused by deficiency of P, K, Ca and Mg is the

(a) bending of leaf tip

(b) formation of anthocyanins

(c) poor development of vasculature

(d) appearance of dead necrotic tissue

Answer

Answer: (d) appearance of dead necrotic tissue

Question 2.

Function of zinc is

(a) Closing of stomata

(b) Biosynthesis of 3-IAA

(c) Synthesis of chlorophyll

(d) Oxidation of carbohydrate

Answer

Answer: (c) Synthesis of chlorophyll

Question 3.

Which of the following is a group of micronutrients?

(a) Ca, Zn, B

(b) Fe, Mn, Cu

(c) Cl, C, Ca

(d) Ni, Mo, H

Answer
Answer: (b) Fe, Mn, Cu
Explanation:
Iron, mangenese and copper are micronutrients.
Question 4.
The process of conversion of NO_2^- to N_2 is called
(a) nitrification
(b) ammonification
(c) denitrification
(d) nitrogen fixation
Answer
Answer: (c) denitrification
Explanation:
The process of conversation of NO_2^- to N_2 is called denitrification.
Question 5.
The formation of first stable product of nitrogen fixation is catalysed by enzyme
(a) dehydrogenase
(b) nitrogenase
(c) isomerase
(d) none of these
Answer
Answer: (b) nitrogenase
Explanation:
The first stable product of nitrogen fixation is ammonia obtained from atmospheric nitrogen catalysed enzyme nitrogenase.
Question 6.
Manganese toxicity leads to deficiency of
(a) iron
(b) calcium
(c) magnesium
(d) all of the above
Answer
Answer: (d) all of the above
Explanation:
Manganese toxicity causes deficiency of iron, magnesium and calcium.
Question 7.
Chlorosis will occur if a plant is grown in
(a) dark
(b) shade
(c) strong light
(d) Fe – free medium
Answer

Answer: (d) Fe – free medium
Question 8.
Choose the correct function of magnesium.
(a) It is a constituent of several coenzyme.
(b) It activates the enzymes of respiration and photosynthesis.
(c) It activates enzyme catalase.
(d) It helps in maintaining anion-cation balance.
Answer
Answer: (b) It activates the enzymes of respiration and photosynthesis.
Explanation:
Magnesium is absorbed by plants as Mg^{2+}
It activates the enzymes of respiration and photosynthesis.
It is involved in the synthesis of DNA RNA.
It is the constituent of ring structure of chlorophyll.
It helps to maintain ribosome structure.
Question 9.
Mineral salts which are absorbed by the roots from soil are in the form of
(a) Dilute solution
(b) Very concentrated solution
(c) Concentrated solution
(d) Very dilute solution
Answer
Answer: (d) Very dilute solution
Question 10.
Which one of the following mineral elements plays an in biological nitrogen fixation?
(a) Copper
(b) Manganese
(c) Zinc
(d) Molybdenum
Answer
Answer: (d) Molybdenum
Question 11.
Oxygen scavangers present in root nodules of legumes is
(a) haemoglobin
(b) leg haemoglobin
(c) cyano haemoglobin
(d) none of these
Answer
Answer: (b) leg haemoglobin
Explanation:
Leg-haemoglobin is the oxygen scavanger in root nodules of legumes.

Question 12.
Which one of the following is not a micronutrient?
(a) Magnesium
(b) Molybdenum
(c) Boron
(d) Zinc
Answer
Answer: (a) Magnesium
Question 13.
Which of the following is not a macronutrient
(a) iron
(b) calcium
(c) manganese
(d) phosphorus
Answer
Answer: (c) manganese
Question 14.
Insectivorous plants grow where
(a) There is carbohydrate deficient soil
(b) There is nitrogen deficient soil
(c) Vitamin c is required
(d) Hormones are required
Answer
Answer: (b) There is nitrogen deficient soil
Question 15.
Phytotron is meant for
(a) Controlled humidity
(b) Induction of mutations
(c) Controlled irradiation
(d) Growing plants under controlled environment
Answer
Answer: (d) Growing plants under controlled environment
Question 16.
Toxicity of which element leads to the appearance of brown spots on leaves
(a) Mg
(b) Mn
(c) Fe
(d) Cu
Answer
Answer: (b) Mn
Explanation:
Toxicity of mangenese leads to the appearance of the brown spots with chlorotic veins.

Question 17.
Presence of phosphorus
(a) brings about healthy root growth
(b) promotes fruit ripening
(c) retards protein formation
(d) none
Answer
Answer: (c) retards protein formation
Question 18.
Which element is required for opening and closing of stomata?
(a) P
(b) K
(c) Ca
(d) Na
Answer
Answer: (b) K
Explanation:
Potassium plays an important role in opening and closing of stomata.
Question 19.
Exanthema is due to deficiency of
(a) B
(b) Mo
(c) Mn
(d) Cu
Answer
Answer: (d) Cu
Question 20.
NPK denotes
(a) Nitrogen, Protein, Kinetin
(b) Nitrogen, Protein, Potassium
(c) Nitrogen, Potassium, kinetin
(d) Nitrogen, Phosphorus, Potassium
Answer
Answer: (d) Nitrogen, Phosphorus, Potassium

Solutions for Class 11 Biology Chapter 12 Mineral Nutrition:

Section Name	Topic Name
12	Mineral Nutrition
12.1	Methods to Study the Mineral Requirements of Plants
12.2	Essential Mineral Elements

12.3	Mechanism of Absorption of Elements
12.4	Translocation of Solutes
12.5	Soil as Reservoir of Essential Elements
12.6	Metabolism of Nitrogen
12.7	Summary

TEXTBOOK QUESTIONS SOLVED

1.'All elements that are present in a plant need not be essential to its survival'. Comment.

Soln. Most of the mineral elements present in the soil enter plants through roots but all of these may not be essential for their survival. Some are absorbed and accumulated by plant only because they are present in excess amount. For example plants growing near nuclear test sites take up strontium, even though it is not required by them. Thus, an essential element is that which is necessary for supporting normal growth and reproduction, its requirement must be specific i.e. its deficiency cannot be met by supplying other element and it must be directly involved in the metabolism of plant.

2.Why is purification of water and nutrient salts so important in studies involving mineral nutrition using hydroponics?

Soln. Impure water and salts contain a large number of soluble minerals and impurities. When such water and salts are used as solution culture for growing plants in hydroponics then the impurities will interfere with the experiment and will not give correct result about the essentiality of a mineral element. Therefore, purified water with defined mineral nutrients are used in hydroponics.

3.Explain with examples:macronutrients, micronutrients, beneficial nutrients, toxic elements and essential elements.

Soln. Macronutrients : Those elements which are generally present in plant tissues in large amounts (in excess of 10 mmole Kg^{-1} of dry matter) and are involved in the synthesis of organic molecules and development of osmotic potential are called macronutrients or macroelement, e.g. carbon, hydrogen, oxygen, nitrogen, sulphur, potassium, calcium and magnesium etc.

Micronutrients : Those elements which are required by plants in'very small amounts (less than 10 mmole Kg^{-1} of dry matter) are called micronutrients, e.g. iron, zinc, manganese, boron, copper, molybdenum, chlorine and nickel. These elements are mostly involved in the functioning of enzymes as cofactor or metal activators.

Beneficial nutrients : Those elements which are required by higher plants along with the macro and micronutrients are called beneficial nutrients, e.g. cobalt, silicon, sodium and selenium.
Toxic elements : Any mineral element if supplied to plant tissue in such concentration that it reduces the dry weight of tissues by about 10 percent, is called toxic element. e.g. manganese toxicity leads to the appearance of brown spots surrounded by chlorotic veins. Excess of manganese induces deficiency of iron, magnesium and calcium.
Essential elements : Any element required by living organisms to ensure normal gfbwth, development, maintenance, metabolism and causes deficiency symptoms if not supplied to the plant from external medium is called essential element, e.g. C, H, O, N, P, K, S, Mg, Ca, Mn, Cu, Mo, Zn, B, Cl, etc. Potassium plays an important role in opening and closing of stomata, protein synthesis etc. Magnesium is found in chlorophyll and phosphorus in ATP. Mg^{2+} is an activator for both ribulose bisphosphate carboxylase-oxygenase and phosphsenol pyruvate carboxylase.Zn^{2+} is an activator of alcohol dehydrogenase and Mo of nitrogenase during nitrogen metabolism.

4.Name at least five different deficiency symptoms in plants. Describe them and correlate them with the concerned mineral deficiency.

Soln. Five different deficiency symptoms in plants are:
(i)Chlorosis – It is the loss of chlorophyll leading to yellowing of leaves. This is caused due to the deficiency of N, K, Mg, S and Fe etc.
(ii)Necrosis – Killing or death of tissue particularly leaf is called necrosis. This is caused due to the deficiency of Ca, Mg, Cu and K etc.
(iii)Whiptail – Degeneration of lamina but not of petiole and midrib , caused by deficiency of molybdenum.
(iv)Die back – It is the killing of shoot apex i.e. stem tip and young leaves. This is caused due to the deficiency of K and Cu.
(v)Little leaf disease – Small sized leaves, caused by zinc deficiency.

5.If a plant shows a symptom which could develop due to deficiency of more than one nutrient, how would you find out experimentally, the real deficient mineral element?

Soln. Deficiency symptoms are first studied by means of pot and culture experiments. Rapidly growing plants which develop characteristic symptoms are used in culture experiments. They are called test (= indicator) plants. They are then grown in soil under test in small pots. The results are compared to know the deficiency elements. Similar tests are performed with selected crops.

6.Why is it that in certain plants deficiency symptoms appear first in younger parts of the plant while in other they do so in mature organs?

Soln. The parts of the plants that show the deficiency symptoms depend on the mobility of the element in the plant. For elements that are actively mobilised within the plants and exported to young developing tissues, the deficiency symptoms tend to appear first in the older tissues. For example, the deficiency symptoms of nitrogen, potassium and magnesium are visible first in the senescent leaves. In older leaves,biomolecules containing these elements are broken down, making these elements available for mobilising to younger leaves. The deficiency symptoms tend to appear first in the young tissues whenever the elements are relatively immobile and are not transported out of the mature organs, for example, elements like sulphur and calcium are a part of the structural component of the cell and hence are not easily released.

7.How are the minerals absorbed by the plants?

Soln. Plants absorb their mineral salt supply from the soil through the roots from the zones of elongation and root hair. The minerals are absorbed as ions which are accumulated by the plants against their concentration in the soil. Plant shows two phases in mineral absorption – initial and metabolic. In the initial phase there is a rapid uptake of ions into outer or free space of the cells (apoplast) that comprises of intercellular spaces and cell walls. Ions absorbed in free space are freely exchangeable, e.g., replacement of unlabelled K+ ions with labelled K+ ions. In the metabolic phase the ions pass into inner space comprising of cytoplasm and vacuole. In the inner space the ions are not freely exchangeable with those of external medium. Entry of ions into outer space is passive absorption as no energy is required for it. Absorption of ions into inner space requires metabolic energy. It is, therefore, an active absorption. Movement of ions into cells is called influx while movement of ions out of the cells is called efflux.

8.What are the conditions necessary for fixation of atmospheric nitrogen by Rhizobiuml What is their role inN_2fixation?

Soln. The conditions necessary for nitrogen fixation by Rhizobium are :

(i) Presence of enzyme nitrogenase.

(ii)A protective mechanism for the enzyme nitrogenase against O_2

(iii)A non-heme iron protein-ferrodoxin as an electron carrier.

(iv)The hydrogen donating system (viz, pyruvate, hydrogen, sucrose, glucoseetc).
(v) A constant supply of ATP.
(vi)Presence of thiamine pyrophosphate (TPP), coenzyme-A, inorganic phosphate and Mg^{++} as co-factors.
(vii)Presence of cobalt and molybdenum,
(viii) A carbon compound for trapping released ammonia.
In the process of biological nitrogen fixation by free living and symbiotic nitrogen fixers, the dinitrogen molecule is reduced step by step to ammonia (NH_3) by the addition of pairs of hydrogen atoms. The pyruvic acid mainly serves as an electron donor but in some cases hydrogen, sucrose, glucose, etc., have also been shown to operate. In leguminous plants, the glucose-6-phosphate molecule probably acts as a substrate for donating hydrogen. The overall process occurs in presence of enzyme nitrogenase, which is active in anaerobic condition. The enzyme nitrogenase consists of two sub-units – a non-heme iron protein (or dinitrogen reductase) and an iron molybdenum protein (Mo-Fe protein or dinitrogenase).
The Fe-protein component reacts with ATP and reduces Mo-Fe protein which then converts $N_2$to ammonia. The ammonia is either directly taken by host or is converted to nitrates with the help of nitrifying bacteria (e.g., Nitrosomonas).

9.What are the steps involved in formation of a root nodule?
Soln. Nodule formation involves a sequence of multiple interactions between Rhizobium and roots of the host plant. Main stages in the nodule formation are:
(i) Rhizobia multiply and colonise the surrounding of roots and get attached to epidermal and root hair cells (Figure a).
(ii)The root hair curl and the bacteria invade the root hair.
(iii)An infection thread is produced carrying the bacteria into the inner cortex of the root (Figure b and c).
(iv)The bacteria get modified into rod-shaped bacteroids and cause inner cortical and pericycle cells to divide. Division and growth of cortical and peri cycle cells lead to nodule formation.
(v) The nodule thus formed, establishes a direct vascular connection with the host for exchange of nutrients (Figure d).
(vi)The nodule contains all the necessary biochemical components, such as the enzyme nitrogenase and leghaemoglobin. The enzyme nitrogenase catalyses the conversion of atmospheric nitrogen to ammonia, the first stable product of

nitrogen fixation.

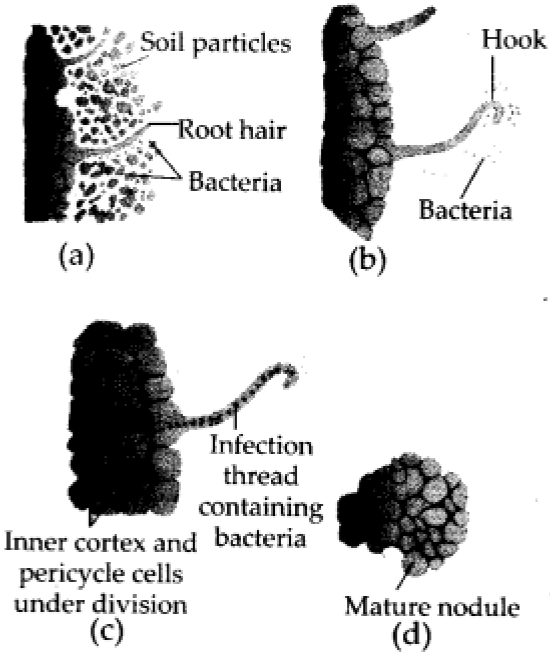


Fig.: Development of root nodule.

10. Which of the following statements are true? If false, correct them.

(a) Boron deficiency leads to stout axis.

(b) Every mineral element that is present in a cell is needed by the cell.

(c) Nitrogen as a nutrient element, is highly immobile in plants.

(d) It is very easy to establish the essentiality of micronutrients because they are required only in trace quantities.

Soln. (a) True.

(b) False. Every mineral element that is present in a cell is not needed by the cell.

(c) False. Nitrogen as a nutrient element is highly mobile in plants.

(d) False. It is very difficult to establish the essentiality of micronutrients because they are required only in trace quantities.

Photosynthesis in Higher Plants Class 5 Notes Biology Chapter 13

All animals including human beings depend on plants for their food. Green plant synthesize the food they need, and for all other organisms depend on them for their needs. Green plants carry out photosynthesis, a physio-chemical processor which they use the light energy to derive the synthesis of organic compounds.

Topic 1 Introduction to Photosynthesis

The energy required by all living organisms comes directly or indirectly from the sunlight.
Thus, sunlight plays an important role in fixation of CO_2 through which, conversion of solar energy into chemical energy takes place. Water plays a significant role during this process.
Hence, photosynthesis is the process by which plants, some bacteria and some protistans uses the energy from sunlight to produce sugar, which through cellular respiration produce ATP, the fuel used by all living organisms.

Photosynthesis is an important phenomenon due to the following two reasons
(i) It is the primary source of all food on the earth.
(ii) It is also responsible for the release of oxygen into the atmosphere by green plants.
Photosynthesis is the only phenomenon of biological importance that can harvest the energy of sunlight.

Requirements of Photosynthesis
On the basis of outline knowledge about the role of light, green plants, CO_2 etc in the process of photosynthesis, several simple experiments might be performed

indicating that chlorophyll, light and carbon dioxide are essential components for photosynthesis to take place.

Necessity of Chlorophyll (Green Pigment of Leaf)
To start with this experiment two leaves are taken, one is a variegated leaf or a leaf that must partially covered with black paper and another leaf that must be exposed to light. When these leaves are tested for presence of starch, it was observed that photosynthesis had occurred only in the green parts of the leaves in the presence of light, which ensures that chlorophyll is essential for photosynthesis.

Necessity of Carbon Dioxide
To initiate the half leaf experiment (given by Moll), a part of leaf is enclosed in a test tube. The test tube contains some cotton soaked in KOH (KOH is used because it absorbs carbon dioxide) and the another half of leaf is exposed to light.

The set up is then allowed to stand in light for about few hours, when starch test was done, it was observed that the exposed part of leaf was tested positive for starch while, the portion that was enclosed in the tube tested negative. This indicates that, the CO_2 is also essential for photosynthesis to take place.

The difference between the two parts of the leaves in the Moll's half leaf experiment was due to the difference in the availability of CO_2 outside and its absence inside the bottle.

Necessity of Light
The rate of photosynthesis is directly proportional to the intensity of light. The necessity of light for photosynthesis can be shown by fixing a dark paper on leaf of well watered, but destarched plant (plant can be destarched, by placing it in dark for 48 hours).

After fixing paper, the set-up is exposed to sunlight for 2-6 hrs. After removing paper, the test for starch is performed over leaf. Starch is produced only in area that received light, shows that light is necessary for photosynthesis.

Necessity of Water
Through radio labelling of oxygen in water molecule, it is confirmed that the 02 released during photosynthesis comes from H_2O, not CO_2.

Early Experiments
Study of photosynthesis started about hundreds of years ago. Prior to that researchers used to believe that plants gets all of their nourishment from soil only by the means of roots. Thus, several simple experiments led to the development of understanding of the process involved. Some early experiments performed by different scholars are as follows.

Joseph Priestley
He performed a series of experiments in 1770s that revealed about the essentiality of air in the growth of green plants. He observed that a burning candle or a respiring mouse in a closed space, (i. e., bell jar) soon gets extinguished and died due to suffocation respectively, because burning candle and animal that breathe the air soon get damages.

On the other hand after placing a mint plant in the bell jar along the burning candle and mouse, he observed that the mouse stayed alive and also the candle continue to burn for a longer time.

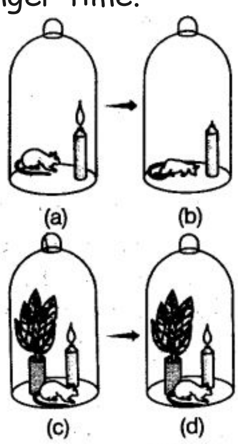


Fig.13.1 Priestley's experiment (a),(b)Mouse dies in foul air (c), (d) Mouse survives in air purified by mint plant.

Conclusion
Priestley hypothesized that the foul air produced by the burning of candles and mouse respiration could be converted into pure air by plant (mint plant in this case).

Jan Ingenhousz (1730-1799)

He performed his experiments by using same set-up used by Priesdey. In his experiment with an aquatic plant, he showed that in bright sunlight, formation of small bubbles take place around the green parts, while in the dark, formation of those bubbles did not take place.

He did this by placing the experimental set-up once in the dark and once in the sunlight. The bubbles that he observed were of oxygen and showed that only green parts of plants could release oxygen.

Conclusion

He thus, concluded that sunlight is essential for the plant that purifies the foul air produced by burning candles or by breathing of animals.

Julius Von Sachs

He with his experiments in 1854 provided evidence that glucose is produced when plants grow, which is usually stored as starch. He later showed that a green substance, i. e., chlorophyll is found to be located in special bodies called chloroplast in plant cells.

Conclusion

He came to the conclusion that green parts are the place in the plants where production of glucose takes place and the same is stored in the form of starch.

The Engelmann (1843-1909)

He determined the action spectrum of photosynthesis by performing the interesting experiment with the help of a green alga, Cladophora. He splits light into its spectral components by using prism. He then illuminated the alga placed in a suspension of aerobic bacteria.

The bacteria were used to detect the sites of O_2 evolution. On doing so, he noticed that the accumulation of bacteria was mainly in the region of the blue and red light of the split spectrum.

Conclusion

By the work done by him at first, action spectrum of photosynthesis was thus described, which roughly resembles the absorption spectra of chlorophyll-a and b.

Therefore, the key features of the process of photosynthesis were known by the middle of the nineteenth century, which detailed that plants acquire light energy harvested from sunlight for the formation of carbohydrates (food) from CO_2 and water.

The empirical equation thus, determined the totalprocess of photosynthesisfor organisms that evolves oxygen is understood as

$$nCO_2 + nH_2O \xrightarrow{\text{Light}} [CH_2O]_n + O_2$$

Cornelius Van Neil (1897-1985)
He was a microbiologist, who made a significant contribution on the basis of his studies of purple and green bacteria (photosynthetic bacteria) in understanding the photosynthesis. He demonstrated that during the process of photosynthesis, the hydrogen from a suitable oxidisable compound transferred, which reduces CO_2 to carbohydrates in the presence of sunlight.

$$2H_2A + CO_2 \xrightarrow{\text{Light}} 2A + CH_2O + H_2O$$

With the help of this, he reaches to the conclusion that, photosynthesis is a light dependent phenomenon.
Further, he states that in photosynthetic bacteriaH2S acts as a hydrogen donor, which gets oxidised to sulphur, i.e., they do not evolve O_2 during the process of photosynthesis. While in case of green plants H_2O acts as a hydrogen donor, which evolves O_2 as its oxidation product.
Thus, he inferred that O_2, which is evolved by the green plants comes from the water (H_2O) not from the CO_2 N (later proved by the use of radioisotopic techniques).
Thus, the overall reaction of the photosynthesis is represented as

$$6CO_2 + 12H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6\,O_2$$

It is also to be noted that it is not a single step reaction that determines the process of photosynthesis instead it is a multi step process.

Conclusion
He concluded that the light is necessary to oxidize the photosynthetic substrate (H_2S – Photosynthetic bacteria) and (H_2O-Green plants) and release byproduct sulphur and 02 in Bacteria and Green plants respectively. In absence of sunlight, this process does not occur.

Chloroplasts: The Site of Photosynthesis

These are the green plastids that function as the site of photosynthesis, i.e., helps in the synthesis of organic food.
The process of photosynthesis takes place in the green leaves of the plants because chloroplasts are abundantly present in the mesophyll cell of the leaves.

Chloroplast aligned themselves with their flat surfaces parallel to the walls of the mesophyll cells under optimum light intensities and they would be perpendicular to the walls of the mesophyll cells when the intensity goes very high.
Chloroplast is double membranous, DNA containing cell organalle.

Internally, a chloroplast contains a proteinaceous matrix or fluid called stroma, the membrane system called lamellae or thylakoids. At some places, the thylakoid gets aggregated to form stacks of discs, called
grana.

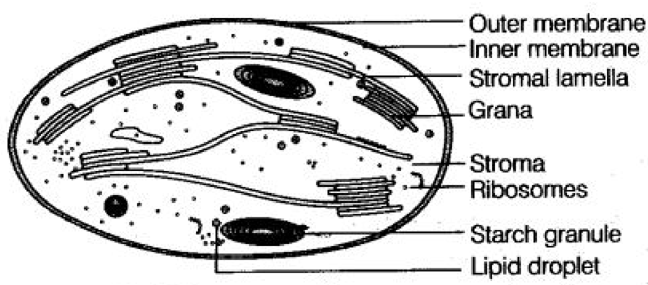


Fig. 13.2 Diagrammatic representation of an electron micrograph of a section of chloroplast

The clear division of labour occurs within the chloroplasts, i.e., the membrane system is responsible for the synthesis of ATP and NADPH (photochemical phase), whereas the stroma has enzymes, which are responsible for the reduction of carbon dioxide into carbohydrates and formation of sugars.

As the former sets of reactions are dependent on light so are called light reactions while, the latter is dependent on the products of light reactions, i.e., ATP and NADPH (and independent from direct sunlight), thus are called dark reactions. It is to be noted that dark reactions does not rely that they occur in darkness or that they are not light dependent.

Pigments Involved in Photosynthesis
The pigments involved in the process of photosynthesis are called photosynthetic pigments. These pigments provides different shades of green in the leaves in different plants or in the leaves of same plant.
These pigments can easily be separated out by chromatographic technique (paper

chromatography). On the basis of their significance, the photosynthetic pigments are of two types
(i) Primary pigments The pigment forms the main molecule of photosystem, e.g., Chlorophyll- a, b.

(ii) Accessory pigments. These support the function of primary pigments, e.g., Xanthophylls and carotenoids.
A cinematographic separation of the leaf pigments shows that it is not only the single pigment, which is responsible for the colour in the leaves. Instead the different shades in leaf are due to four different pigments that have different ability to absorb light at specific wavelength.

Different pigments present in leaf described below
(a) Chlorophyll-a ($C_{55}H_{72}O_5N_4M_g$) This is bright or blue green in the chromatogram. It is known to be the chief plant pigment associated with photosynthesis.
(b) Chlorophyll-b ($C_{55}H_{70}O_6N_4M_g$) This is yellow green in colour.
(c) Xanthophylls This is yellow in colour. These pigments are oxidised carotenoids.
(d) Carotenoids This is yellow to yellow-orange in colour. They are also known as 'antenna pigment'.
Chlorophyll is the most abundant plant pigment found if the plants in the world. It contains magnesium (Mg^{+2}) metal as its constituents.

Absorption Spectrum
It is the curve that shows the amount of different wavelength of lights absorbed by a substance. The graph given below shows the ability of chlorophyll-a to absorb lights of different wavelength.
Chtorophyll-a shows the maximum absorption peak at 450 nm and also shows another peak at 650 nm.

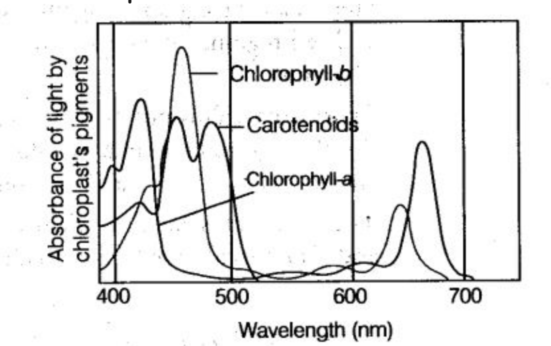


Fig. 13.3 Graph showing the absorption spectrum of chlorophyll a, b, and the carotenoids

Absorption spectrum is constituted by the pigments like violet, blue, orange and

red (400-500 and 600-700 nm).
The Emission spectrum is constituted by yellow and yellow-green pigment (500-600 nm).

Action Spectrum
It is the curve that depicts the relative rates of photosynthesis at different wavelengths of light. Now another graph given below, shows the wavelength at which maximum photosynthesis occurs at blue, violet and red wavelength in a plant (which is shown by chlorophyll-a).

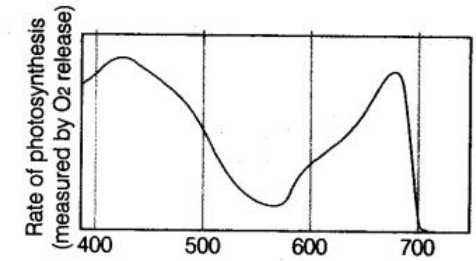


Fig. 13.4 Graph showing action specturm of photosynthesis spectrum of photosynthesis

Hence, this concludes that chlorophyll-a is the chief pigment, which is majority responsible for the photosynthesis.The another graph given below show the action spectrum of photosynthesis, which coincide closely to the absorption spectrum of chlorophyll.

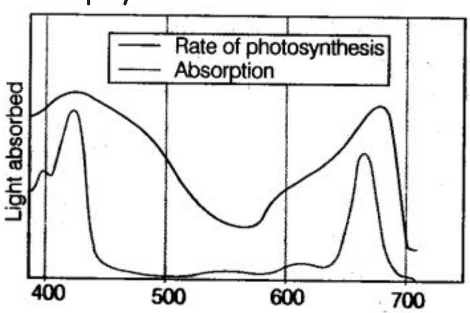


Fig. 13.5 Superimposed on absorption spectrum of chlorophyll a

Hence, all three graphs together shows that the major part of the photosynthesis takes place in the blue and red regions, while some of the photosynthesis takes place at other wavelengths also in the visible spectrum.
Apart from chlorophyll-a (the major pigment,) which is mainly responsible for trapping of light, other thylakoid pigments such as chlorophyll-a, xanthophylls and carotenoids also absorb light, transferring energy to chlorophyll-a. These pigments are called accessory pigments.
These pigments enable a wider range of wavelength of incoming light to be utilised

for photosynthesis and also provide protection to chlorophyll-a from photooxidation.

Photosynthetically Active Radiation (PAR)
The region of wavelength in which photosynthesis takes place normally. It ranges from 0.4μm to 0.7μm (400-700 nm).

Assimilatory Power
The chemicals (ATP and NADPH) synthesised in photosynthesis, termed as assimilatory power. They are used in the process to reduce CO_2 into carbohydrates.

Topic 2 Mechanism of Photosynthesis

It was observed that the rate of photosynthesis is directly proportional to the intensity of light, i.e., rate increases with the increase in intensity of light till the plant achieved the saturation point.
The process ofphotosynthesis takes place in following two steps
(i) Light reaction or the photochemical phase.
(ii) Dark reaction or the biosynthetic phase.

Light Reaction (The Photochemical Phase)
Light reaction includes the following steps, i. e., absorption of light, splitting of water, release of oxygen and finally the formation of high energy chemical intermediates, i.e., ATP and NADPH. '
During the course of light reaction, light is trapped by photosynthetic pigments present in the quantasomes of grana thylakoids.

These photosynthetic pigments are organised into two discrete photochemical Light Harvesting Complexes (LHCs) known as Photosystem-I (PS-I) and Photosystem-II (PS-II).

Photosystems
The light harvesting complexes or photosystems are made up of hundreds of pigment molecules bounded by proteins. Each photosystem has a photocentre or reaction centre, where actual reaction takes place.

This reaction centre contains a special chlorophyll- molecule is fed by hundred other pigment molecules forms the light harvesting system called antennae. These antennae molecule absorb light of different wavelength, but shorter than reaction centre in order to make photosynthesis more efficient.

These photosystems are, named according to the sequence of their discoveries not in the sequence in which function during the light reaction.

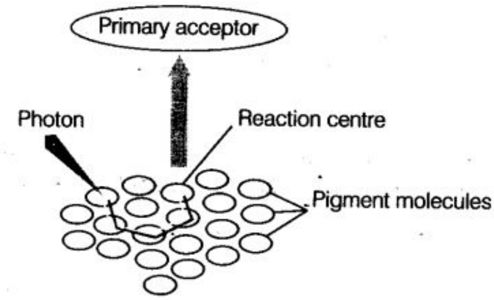


Fig. 13.6 The light harvasting complex

The reaction centre is different in both the photosystem as given below
(i) In PS-I, the reaction centre or chlorophyll-a has peak of absorption at 700 nm, known as P_{700}.
(ii) In PS-II, the reaction centre has absorption peak at 680 nm hence, called P_{680}.

Electron Transport
The photosynthetic electron transport chain initiates by the absorbance of light by the photosystem-II. The red light of wavelength 680 nm is absorbed by the reaction centre of photosystem II due to which electrons becomes excited and jump into an orbit away from the atomic nucleus.

These electrons are then picked up by an electron acceptor, which passes them further to electron transport system consisting of cytochromes.

It is to be noted that this movement of electrons is down hill according to the redox potential scale (oxidation-reduction scale). The electrons of the electron transport chain are not used up in the chain instead they are further passed on to the pigments of PS-I.

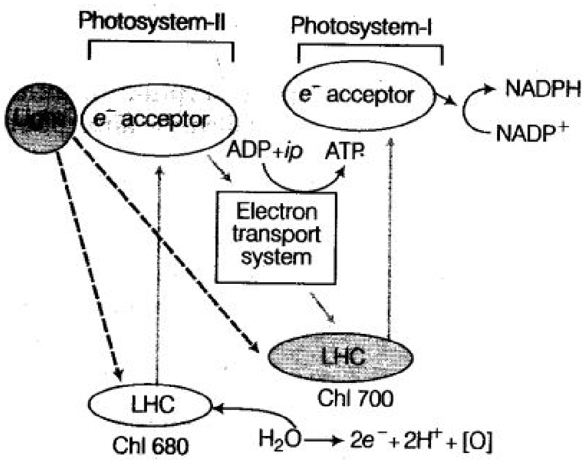


Fig. 13.7 Z-scheme of light reaction

Now, like the PS-II, the electrons in the reaction centre of PS-I also gets excited on receiving red light of wavelength 700 nm and gets transferred to the another electron acceptor with hitter redox potential.
The electrons in this ease also moves downhill.

But this time the electrons does not move to a reaction centre or chlorophyll-a. Instead, moves to a molecule rich in energy and $NADP^+$. On addition of these electrons the $NADP^+$ gets reduced to $NADPH + H^+$.

In 1960, Bendall and Hill discovered the Z-scheme of electron transport. It is a series of reactions that we have just studied above from the whole scheme of electron transfer initiating from PS-II, uphill to the acceptor molecule, down the electron transport chain to PS-I, excitation of electrons and then their transfer to another acceptor and finally downhill to $NADP^+$ in order to get reduced to NADPH and H^+.

Splitting of Water
The electrons are continuously supplied to the photosystems-II by the available electrons, which gets replaced due to the splitting of water. In this process the water splits into protons, electrons and oxygen. The complex for water splitting is associated with the photosystems-II that is located on the inner side of the thylakoid membrane.
These electrons thus, obtained by the splitting of water are needed to replace those electrons which are removed from the photosytems-I thus, are provided by photosystem-II.
$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$

While all the electrons formed, are replaced, the protons gets accumulated in the lumen of the thylakoid and the oxygen gets into the atmosphere.

Photophosphorylation

Photophosphorylation is the process through which, ATP is synthesised from ADP and inorganic phosphate (P) by the cell organelles (like mitochondria and chloroplasts) with the help of energy from solar radiation.
Photophosphorylation in mitochondria is not light dependent, but it uses the energy by oxidation of nutrients to produce ATP, hence it is called oxidative phosphorylation.

The process of photophosphorylation is of two types
i. Non-cyclic Photophosphorylation
Non-cyclic photophosphorylation is type of photophosphorylarion in which both the photosystems (PS-I and PS-II) cooperate in light driven synthesis of ATP. During this cycle, the electron released from PS-II does not return to it hence, it is known as non-cyclic photophosphorylation. Both NADPH and ATP are formed during this reaction.

ii. Cyclic Photophosphorylation
It is the type of photophosphorylation in which only PS-I is taking part and the electron released from the reaction centre P_{700} returns to it after passing through a series of carrier i.e., circulation takes within the photosystem and the phosphorylation occurs due to cyclic flow of electrons.

iii. When non-eyeiie form of photophosphorylation gets stopped under certain conditions, the cyclic photophosphorylation occurs.

The cyclic photophosphorylation takes place in the stromal lamellae of the chloroplast. This happens because the stromal lamellae does not possess enzyme NADP reductase (essential for reducing $NADP^+$ to NADPH) and PS-II. Thus, the excited electrons in the cyclic photophosphoiylation does not pass on to $NADP^+$ instead it gets cycled back to the PS-I complex.

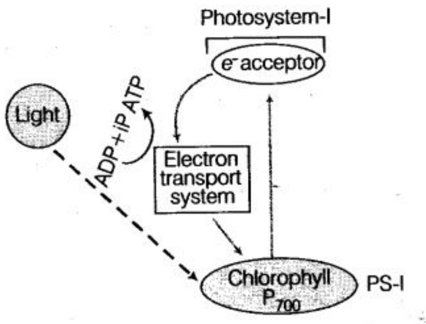


Fig. 3.8 Cyclic photophosphorylation

Hence, through the cyclic flow only the synthesis of ATP takes place.

Chemiosynthetic Hypothesis

This hypothesis was given by Peter Mitchell (1961) in order to explain the ATP synthesis in photosynthesis (also in respiration).

The synthesis of ATP is directly linked to the developinent of a proton gradient across the thylakoid membranes of a chloroplast.

The main difference that lies between the photosynthesis and respiration is the location where the accumulation of protons takes place. In chloroplast (photosynthesis), it occurs in thylakoid lumen while in mitochondria (respiration), it occurs in intermembrane space.

Now, the point arises that what causes the proton gradient across the membrane?

The development of proton gradient results due to the reasons given below

(i) As the water molecule splits into the inner side of the membrane the protons or hydrogen ions that are produced by the water splitting gets accumulate within the thylakoids lumen.

(ii) Transportation of protons takes place across the membrane when the electron moves through the photosystems. The primary acceptor of electron is located towards the outer side of the membrane, which transfers electron to the proton (H^+) carrier and not to the electron carrier.

So, this molecule, while transporting an electron removes a proton from the stroma, thus, release of proton takes place into the inner side, i.e., on the lumen of the membrane.

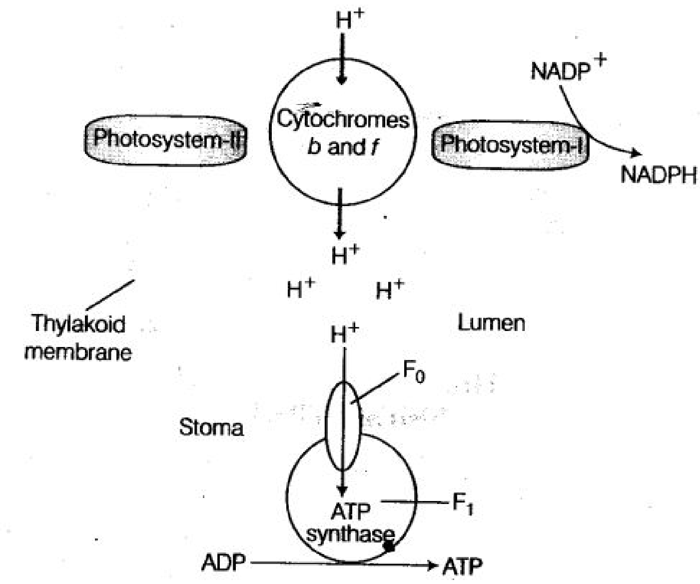


Fig. 13.9 ATP synthesis through chemiosmosis

(iii) The enzyme NADP reductase is present on the stromal side of the membrane. Thus, alongwith the electrons that comes from the acceptor of electrons of PS-I, protons are also necessary to reduce $NADP^+$ to $NADPH + H^+$

Hence, protons in the stroma within the chloroplasts decreases in number, while accumulation of protons takes place in the lumen. Due to which the proton gradient is created across thylakoid membrane, which led to decrease in the pH at the side the lumen.

The gradient is broken down due to the movement of protons across the membrane to the stroma through the transmembrane channel of the F_0 portion of the ATPase enzyme.

Therefore, the proton gradient is important as it is the gradient whose breakdown leads to the release of energy (ATP).

ATPase Enzyme

The enzyme ATPase consists of the following two parts

i. F_0 Particle

This portion remains embedded in the membrane and forms a transmembrane channel, which carries out facilitated diffusion of protons across the membrane.

ii. F_1 Particle

This portion protudes towards the outer surface of the thylakoid membrane which faces the stroma. Conformational change occurs in F_1 particle of ATPase, which caused due to the breakdown of the gradient, which allows the enzyme to synthesise several molecules of ATP.

Thus, the chemiosmosis, for its functioning, requires a membrane, a proton pump, a proton gradient and ATPase enzyme. The ATP thus, produced will be used immediately in the biosynthetic reaction (in stroma), responsible for the fixing of CO_2 and synthesis of sugar.

Dark Reaction (Biosynthetic Phase)
This phase does not require direct sunlight but it depends on the products of the light reaction, i.e., ATP and NADPH beside CO_2 and water that drive the processes leading to the synthesis of food more accurately the sugars.

The O_2 thus, produced in the light reaction of photosynthesis diffuses out of the chloroplast

As soon as the light becomes unavailable, the biosynthetic process continues for sometime and then eventually stops and starts again if the light is made available again.

Originally, this process is known as carbon-fixation or Photosynthetic Carbon Reduction (PCR) cycle.
These reactions are sensitive to temperature change, but are independent of light, hence called dark reaction. This takes place in the stroma of chloroplast.

Thus, assimilation of CO_2 during photosynthesis is of two main types
i. C_3 Pathway This pathway is followed by the plants when first product of CO_2 fixation is a C_3 acid, i.e., PGA.
ii. C_4 Pathway This pathway is followed or shown by the plants in which first product ofCO_2 fixation is a C_4 acid, i. e., OAA.

Calvin Cycle (C_3-Pathway)
This is a cycle biochemical pathway of reduction of CO_2 or photosynthetic carbon, cycle, which was discovered by Calvin. The Calvin cycle runs in all photosynthetic plants, no matter they shows C_3, C_4 or any other pathways. It occurs in stroma of the chloroplast

Primary Acceptor of CO_2 in C_3 Pathway

After a long research and conducting many experiments it was concluded by the scientists that in C_3 pathway, the acceptor molecule is a 5-carbon ketose sugar, i.e., Ribulose 5-phosphate (5 RuBP).

Calvin orC_3 cycle has following three major steps

Calvin or C_3 cycle has following three major steps

Carboxylation (of RuBP)	Reduction (of PGA)	Regeneration (of RuBP)
(1)	(2)	(3)

The steps mentioned above are the major steps. Another steps known as glycolytic reversal or formation of sugar takes place between reduction and regeneration.

1. Carboxylation

It is the most crucial step of the Calvin cycle in which utilisation of CO_2 takes place for the carboxylation of RuBP.

Carboxylation is the process of fixation of CO_2 into a stable organic intermediate.

This reaction is catalysed by the enzyme RuBP carboxylase which finally results in the formation of two molecules of 3-PGA. As the RuBP carboxylase enzyme also has an activity of oxygenation. Thus, it more commonly known as RuBP carboxylase-oxygenase or RuBisCO.

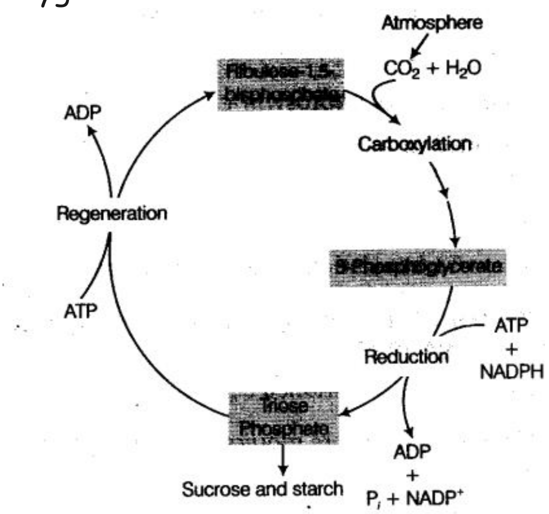


Fig. 13.10 Calvin cycle (C pathway)

$$CO_2 + RuBP + H_2O \xrightarrow[Mg^{2+}]{RuBis\ CO} 2\ (3\text{-PGA})$$

2. Reduction

After the carboxylation reaction, reduction of PGA takes place through a series of reactions leading to the formation of glucose. In this step, the ATP and NADPH (formed during the photochemical reaction) are utilised. It is to be noted that 2 molecules of ATP and 2 molecules of NADPH are utilised in this step for phosphorylation and for the reduction of CO_2 respectively.

Hence, the fixation of 6 molecules of CO_2 and 6 turns of the cycle are required in order to release one molecule of glucose from the pathway.

$$3\,PGA + ATP \longrightarrow 1,3\text{ bisphosphoglyceric acid}$$

$$1,3\text{-bisphosphoglyceric acid} + NADPH + H^{+}\ 3\text{-} \xrightarrow{\text{Reduction}} \underset{(PGAL)}{\text{Phosphoglyceraldehyde}} + Pi + NADP^{+}$$

3. Regeneration

For the continuous and uninterrupted functioning of the Calvin cycle, there must be a regular supply of ATP, NADPH and also sufficient amount of RuBP is required. The regeneration of RuBP (CO_2 acceptor) is a complex process and involves many types of sugar starting from triose (3C) to heptose (7C).

The regeneration step require one ATP molecule for phosphorylation. Hence, for every CO_2 molecule that- enters the Calvin cycle, required are 3 molecules of ATP and 2 molecules of NADPH.

The cyclic phosphorylation takes place in order to meet the difference in the number of ATP and NADPH used in the dark reaction.

Thus, in order to produce one molecule of glucose through the Calvin pathway, 18 ATPs and 12 NADPHs are required.

This can he easily understood by the following table given below

In	Out
6 CO_2	1 glucose
18 ATP	18 ADP
12 NADPH	12 NADP

Photosynthesis in Higher Plants Class 5 MCQs Questions with Answers

Question 1.
The rate of photosynthesis is controlled by
(a) the rate of light reaction
(b) the rate of dark reaction
(c) the rates of both light and dark reactions
(d) none of the above
Answer
Answer: (b) the rate of dark reaction

Question 2.
The end product of the Calvin cycle is ______.
(a) RuBP
(b) PGAL
(c) PGA
(d) ADP + NADP
Answer
Answer: (a) RuBP

Question 3.
The primary carbon dioxide acceptor in C4 cycle is
(a) malic acid
(b) phosphoenol pyruvate
(c) rubisco
(d) aspartic acid
Answer
Answer: (b) phosphoenol pyruvate
Solution :
The primary carbon dioxide acceptor in C4 pathway is phosphoenol pyruvate.
Question 4.
The law of limiting factor was given by
(a) Calvin
(b) Blackman
(c) Priestley
(d) None of these
Answer
Answer: (b) Blackman
Solution :
Law of limiting factor was given by Blackman in 1905.
If a chemical process is affected by more than one factor, then its rate will be detrmined by the factor which is nearest to its minimal value.

Question 5.
The metabolic pathway which produces carbohydrate is
(a) Calvin cycle
(b) Glycolysis
(c) Cyclic electron pathway
(d) Krebs cycle
Answer
Answer: (a) Calvin cycle

Question 6.
Manganese is required in
(a) Chlorophyll synthesis
(b) Nucleic acid synthesis
(c) Plant cell wall formation
(d) Photolysis of water during photosynthesis
Answer
Answer: (d) Photolysis of water during photosynthesis

Question 7.
Oxidative phosphorylation refers to
(a) Anaerobic production of ATP
(b) The citric acid cycle production of ATP
(c) Production of ATP by chemiosmosis
(d) Alcoholic fermentation
Answer
Answer: (c) Production of ATP by chemiosmosis

Question 8.
Which of the following is not an accessory pigment?
(a) Carotene
(b) Chlorophyll a
(c) Chlorophyll b
(d) Xanthophyll
Answer
Answer: (b) Chlorophyll a
Solution :
Chlorophyll a is a primary pigment.

Question 9.
Besides water and CO_2, which is more essential a raw material for food formation
(a) light
(b) oxygen

(c) NAD
(d) mineral salt
Answer
Answer: (a) light

Question 10.
In actively gro – wing young plants, the best data for estimating the rate of photosynthesis would be
(a) ratio of oxygen evolved to carbon dioxide absorbed
(b) increase in fresh weight
(c) increase in dry weight
(d) increase in carbohydrate
Answer
Answer: (a) ratio of oxygen evolved to carbon dioxide absorbed

Question 11.
Discovery of Emerson effect has already shown the
(a) two distinct photochemical reactions
(b) light and dark reactions of photosynthesis
(c) photophosphorylation
(d) photorespiration
Answer
Answer: (a) two distinct photochemical reactions

Question 12.
Translocation of sugar in flowering plants occurs in the form of
(a) glucose
(b) sucrose
(c) starch
(d) maltose
Answer
Answer: (b) sucrose

Question 13.
Where are thylakoids and grana located?
(a) Lysosomes
(b) Mitochondria
(c) Chloroplasts
(d) Golgi apparatus
Answer
Answer: (c) Chloroplasts

Question 14.
Who enunciated the law of limiting factor for photosynthesis?
(a) Robert Emerson
(b) Ruben
(c) Blackman
(d) Calvin
Answer
Answer: (c) Blackman

Question 15.
Which one of the following statement is true for ATP?
(a) ATP is prosthetic part of an enzyme
(b) ATP is an enzyme
(c) ATP is organic ions of enzyme
(d) ATP is a Co-enzyme
Answer
Answer: (d) ATP is a Co-enzyme

Question 16.
Kranz anatomy is a feature of
(a) C3 plants
(b) CAM plants
(c) C4 plants
(d) All of these
Answer
Answer: (c) C4 plants
Explanation:
Kranz anatomy is a feature of C4 plants. Kranz means wreath.
It tells about the arrangement of cells.

Question 17.
Which of the following is a 4-carbon compound?
(a) Oxaloacetic acid
(b) Phosphoglyceric acid
(c) Ribulose biphosphate
(d) Phosphoenolpyruvate
Answer
Answer: (a) Oxaloacetic acid

Question 18.
Which of the following process (C4 cycle) occurs in bundle sheath cells?
(a) Regeneration

(b) Fixation
(c) Carboxylation
(d) Decarboxylation
Answer
Answer: (d) Decarboxylation

Question 19.
Light reactions of photosynthesis occurs in
(a) stroma
(b) thylakoid
(c) grana
(d) cytoplasm of cell
Answer
Answer: (c) grana
Explanation:
Light reactions of photosynthesis occurs in grana.

Question 20.
Water stress causes
(a) opening of stomata
(b) increase in metabolic rate
(c) wilting of leaves
(d) lesser availability of carbon dioxide
Answer
Answer: (c) wilting of leaves
Explanation:
Water stress causes closure of stomata. Since stomata is closed carbon dioxide available to plants is less.
Metabolic rate decreases which causes wilting of leaves.

Solutions for Class 11 Biology Chapter 13 Photosynthesis in Higher Plants:

Section Name	Topic Name
13	Photosynthesis in Higher Plants
13.1	What do we Know?
13.2	Early Experiments
13.3	Where does Photosynthesis take place?
13.4	How many Pigments are involved in Photosynthesis?
13.5	What is Light Reaction?
13.6	The Electron Transport

13.7	Where are the ATP and NADPH Used?
13.8	The C_4 Pathway
13.9	Photorespiration
13.10	Factors affecting Photosynthesis
13.11	Summary

TEXTBOOK QUESTIONS SOLVED

1. By looking at a plant externally can you tell whether a plant is C_3 or C_4 ? Why and how?

Solution: It is not possible to distinguish externally between a C_3 and C4 plant, but generally tropical plants are adapted for C_4 cycle.

2. By looking at which internal structure of a plant can you tell whether a plant is C_3 or C_4 ? Explain.

Solution: C_4 plants live in hot moist or arid and nonsaline or saline habitats. Internally the leaves show kranz anatomy. In kranz anatomy, the mesophyll is undifferentiated and its cells occur in concentric layers around vascular bundles. Vascular bundles are surrounded by large sized bundle sheath cells which are arranged in a wreath-like manner (kranz – wreath). The mesophyll and bundle sheath cells are connected by plasmodesmata or cytoplasmic bridges. The chloroplasts of the mesophyll cells are smaller. They have well developed grana and a peripheral reticulum but no starch. Mesophyll cells are specialised to perform light reaction, evolve 02 and produce assimilatory power (ATP and NADPH). They also possess enzyme PEPcase for initial fixation of CO_2 The chloroplasts of the bundle sheath cells are agranal.

3. Even though very few cells in a C_4 plant carry out the biosynthetic – Calvin pathway, yet they are highly productive. Can you discuss why?

Solution: Since, through C_4 cycle, a plant can photosynthesise even in presence of very low concentration of CO_2 (upto 10 parts per million), the partial closure of stomata due to xeric conditions would not bring much effect. Therefore, the plants can adapt to grow at low water content, high temperature and bright light intensities. This cycle is specially suited to such plants which grow in dry climates of tropics and subtropics. Besides, the photosynthetic rate remains higher due to absence of photorespiration in these plants. It can be visualised that both C_4 cycle and photorespiration are the result of evolution or might have been one of the reasons of evolution for the adaptation of plants to different environments. C_4 plants are about twice to efficient as C_3 plants in converting solar energy into production of dry matter.

4. RuBisCO is an enzyme that acts both as a carboxylase and oxygenase. Why do you think RuBisCO carries out more carboxylation in C_4 plants?

Solution: RuBisCO is an enzyme which acts both as carboxylase (carboxylation during photosynthesis) and oxygenase (during photorespiration). But RuBisCO carries out more carboxylation in C4 plants. In C_4 plants, initial fixation of carbon dioxide occurs in mesophyll cells. The primary acceptor of C02 is phosphoenol pyruvate or PER It combines with carbon dioxide in the presence of PEP carboxylase or PEPcase to form oxaloacetic acid or oxaloacetate. Malic acid or aspartic acid is translocated to bundle sheath cells through plasmodesmata. Inside the bundle sheath cells they are decarboxylated (and deaminated in case of aspartic acid) to form pyruvate and CO_2 . CO_2 is again fixed inside the bundle sheath Cells through Calvin cycle. RuBP of Calvin cycle is called secondary or final acceptor of CO_2 in C_4 plants. Pyruvate is sent back to mesophyll cells.

5. Suppose there were plants that had a high concentration of chlorophyll b, but lacked chlorophyll a, would it carry out photosynthesis? Then why do plants have chlorophyll b and other accessory pigments?

Solution: Plants that do not possess chlorophyll a will not carry out photosynthesis because it is the primary pigment and act as the reaction centre. It performs the primary reactions of photosynthesis or conversion of light into chemical or electrical energy. Other photosynthetic pigments are called accessory pigments. They absorb light energy of different wavelengths and hence broaden the spectrum of light absorbed by photosynthetic pigments. These pigments hand over the absorbed energy to chlorophylla.

6. Give comparison between the following:

(a) C_3 andC_4 pathways

(b) Cyclic and non-cydic photophosphorylation

(c) Anatomy of leaf in C3 and C_4 plants.

Solution: (a) The differences between C_3 and C_4

	C_3 pathway	C_4 pathway
(i)	Ribulose biphosphate is the first acceptor of CO_2.	Phosphoenol pyruvate is the first acceptor of CO_2, while ribulose biphosphate is the second acceptor.
(ii)	Phosphoglyceric acid is the first product.	Oxaloacetic acid is the first product.
(iii)	The plants operate only Calvin cycle.	Plants operate a dicarboxylic acid cycle in addition to Calvin cycle.
(iv)	CO_2 compensation point is 25 – 100 ppm.	CO_2 compensation point is 0 – 10 ppm.
(v)	Mesophyll cells perform complete photosynthesis.	Mesophyll cells perform only initial fixation.

(vi)	The rate of carbon assimilation is slow.	The rate of carbon assimilation is quite rapid.
(vii)	The plants are unable to perform photosynthesis at very low CO_2 concentration (say 10 – 50 ppm).	Photosynthesis continues even at very low CO_2 concentration of 10 – 50 ppm.
(viii)	The cycle operates in all plants.	The cycle is found only in some plants like maize, sugarcane etc.
(ix)	Fixation of one molecule of CO_2 uses 3 ATP and 2NADPH.	Fixation of one molecule of CO_2 requires 5 ATP and 2NADPH.

(b) The differences between cyclic and non- cyclic photophosphorylation are as follows :

	Cyclic photophos-phoryaltion	Non-cyclic photo-phosphorylation
(i)	It is performed by photosystem I independently.	It is performed by collaboration of both photosystems I and II.
(ii)	It is not connected with photolysis of water. Therefore, no oxygen is evolved.	It is connected with photolysis of water and liberation of oxygen.
(iii)	It synthesises only ATP.	Non-cyclic photophosphorylation is not only connected with ATP synthesis but also production of NADPH.
(iv)	It operates under low light intensity, anaerobic conditions or when CO_2 availability is poor.	Non-cyclic photophosphorylation takes place under optimum light, aerobic conditions and in the presence of carbon dioxide.
(v)	It occurs mostly in stromal or intergranal thylakoids.	It occurs in the granal thylakoids.

(vi)	ATP synthesis is not affected by DCMU.	DCMU inhibits non-cyclic photo-phosphorylation.

(c) Differences between the leaf anatomy of C_3 and C_4plants are as follows :

	C_3 plants	C_4 plants
(i)	The leaves do not possess kranz anatomy.	The leaves have kranz anatomy.
(ii)	Chloroplasts do not have peripheral reticulum.	Chloroplasts have peripheral reticulum.
(iii)	Chloroplasts are of one type (monomorphic).	There are two types of chloroplasts (dimorphic).
(iv)	Bundle sheath cells usually do not contain chloroplasts.	Bundle sheath cells possess prominent chloroplasts.
(v)	In higher plants, operating C_3 cycle, all the chloroplasts are granal.	There are two types of chloroplasts, granal in mesophyll cells and agranal in bundle sheath cells.
(vi)	Mesophyll cells perform complete photosynthesis.	Mesophyll cells perform only initial fixation.
(vii)	Perform photosynthesis only when stomata are open.	Perform photosynthesis even when stomata are closed (from CO_2 produced in respiration).

7. Look at leaves of the same plant on the shady side and compare it with the leaves on the sunny side. Or ompare the potted plants kept in the sunlight with those in the shade. Which of them has leaves that are darker green? Why?

Solution: The leaves of the shaded side are darker green than those kept in sunlight due to two reasons:

(i) The chloroplasts occur mostly in the mesophyll cells along their walls for receiving optimum quantity of incident light.

(ii)The chloroplasts align themselves in vertical position along the lateral walls of high light intensity and along tangential wails in moderate light.

8. The given figure shows the effect of light on the rate of photosynthesis. Based on the graph, answer the following questions.

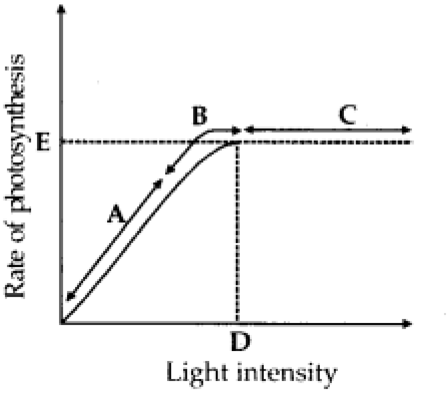


Fig.: Graph showing effect of light intensity on the rate of photosynthesis

(a) At which point/s (A, B or C) in the curve is light limiting factor?
(b) What could be the limiting factor/s in region A?
(c) What do C and D represent on the curve?

Solution: (a) At regions A and B light is the limiting factor.
(b) In the region A', light can be a limiting factor.
(c) C is the region where the rate of photosynthesis is not increased when light intensity is increased. D is the point where some other factors become limiting.

9. Why is the colour of a leaf kept in the dark frequently becomes yellow, or pale green? Which pigment do you think is more stable?

Solution: Carotenoid pigments are found in all photosynthetic cells. They are accessory pigments also found in roots, petals etc. These pigments do not breakdown easily thus temporarily reveal their colour due to unmasking, following breakdown of chlorophylls. Thus the colour of leaf kept in dark is yellow or pale green.

Respiration in Plants Class 5 Notes Biology Chapter 14

All living organisms require a continuous supply of energy for their survival. Energy is used to carry out various functions such as uptake of materials, absorption, growth, development, movement and even breathing. About 50% of the energy produced by the cell is utilized by these cellular activities and rest of it is changed into heat and get lost. Now, the question arises from where does this energy comes to carry out all these processes of life.

Topic 1 Respiration : The Basics

We eat food in order to obtain energy. The food we eat in the form of macro molecules is oxidized to fulfill energy requirement of body for carrying out all the basic life processes.

As we have already studied in last chapter, that only green plants and cyanobacteria can prepare their own food by the process called photosynthesis. They use trapped energy in order to obtain their food by converting light energy into chemical energy, which thereby gets stored into the bonds of carbohydrates such as glucose, sucrose, starch, etc.

But all cells, tissues and organs in plants do not photosynthesise instead, photosynthesis takes place in only some parts of plants, i.e., only cells that contain chloroplasts (mosdy areas located in superficial layers).

Hence, all other organs, tissues and cells in green plant that are non-green are need food for oxidation. Hence, food has to be translocated from the green parts to the non-green parts for oxidation processes.

Need of Photosynthesis
Animals on the other hand are heterotrophic in nature, i.e., they either obtain their food directly from the plants (herbivores) or indirectly, dependent on herbivores for their food (carnivores).

Saprophytes are dependent on dead and decaying matter for their food (e.g., Fungi). Thus, it can be concluded that all the food that is respired for life processes ultimately comes from photosynthesis.

Cellular Respiration
Cellular respiration or the mechanism of breakdown of food materials within-the cell to release energy and trapping the same energy for synthesis of ATP.

Respiration is the process of breaking of the C-C bonds of complex compounds through oxidation within the cells, leading to release of considerable amount of energy.

It is to be noted that site of breaking down of complex molecules to yield energy is cytoplasm and mitochondria (also only in eukaryotes) which is different from the site of photosynthesis, which is chloroplast in plants.

Respiratory Substrates
The compounds that are oxidised during the process of respiration are called respiratory substrates. Carbohydrates are used as major respiratory substrates are oxidised in high amounts, to release energy, but under some conditions in some plants, proteins, fats and organic acids are also used as respiratory substrates.

Differences between Respiration and Combustion

Respiration	Combustion
It is the breakdown of complex compounds through oxidation within the cells, leading to release of considerable amount of energy.	Combustion is the complete burning of glucose, which produces CO_2 and H_2O and yield energy which is given out as heat.
It is a controlled biochemical process.	It is an uncontrolled physico-chemical process.
Many chemical bonds break simultaneously releasing large amount of energy.	Chemical bonds break one after another to release energy.
Enzymes are involved.	Enzymes are not involved.
Only a part of energy is lost as heat.	Most of the energy is liberated as heat.
A number of intermediates are formed for the synthesis of different organic compounds.	No intermediates are produced in this case.

ATP : Energy Currency of the Cell

During the process of oxidation of food within a cell, all the energy contained in the respiratory substrates is not released free into the cell, or in a single step. Instead it gets released in a series of step-wise reactions controlled by enzymes and is trapped as chemical energy in the form of ATP.

Hence, the energy released in respiration by the process of oxidation is not used directly but is used in synthesising ATP (which is utilised whenever energy needs to be utilised).

Thus, it is said that ATP acts as the energy currency of the cell. The energy trapped in ATP is utilised in many energy requiring processes of the organisms, and the carbon skeleton produced during respiration is used as precursors for the biosynthesis of other molecules in a cell.

Do Plants Breathe : Exchange of Gases in Plants

For the process of respiration, plant takes O_2 and releases CO_2. Plants have stomata and lenticles for gaseous exchange instead of specialised organs that are present in animals for exchange of gases.

Following are the reasons which shows, how plants can get along without respiratory organs

(i) Every part of the plant has the ability to take care of its own needs of gas exchange and also very little transport of gases occur from one part of the plant to another.

(ii) It is only during the process of photosynthesis that large volumes of gases are exchanged and each leaf of the plant has ability to take care of its own needs during these periods.
Thus, when cells photosynthesis, availability of O_2 is not a problem in these cells due to a continuous release of O_2 that takes place within the cell.

(iii) Gases may easily diffuse in large, bulky plants as distance for diffusion is not so great because living cells in a plant are located quite close to the surface of the plant.

In case of stems, which are thick and woody in nature, the organisation of living cells is in the form of thin layers, which are found inside and beneath the bark. Like leaves which have stomata for gaseous exchange, these stems also have openings called lenticels. Internal cells are dead and provide only mechanical support to the plant.

This depicts that most cells of plant have atleast a part of their surface in contact with the air. The loose packing of parenchyma cells in leaves, stems and roots and provides an interconnected network of air spaces helps in facilitating this process.

Types of Respiration
We know that during the process of respiration, utilisation of O_2 takes place with the release of CO_2, water and energy as products.
According to the dependence of cells on oxygen, cellular respiration may be classified into two types as given below

1. Aerobic Respiration
This is the type of respiration in which organism utilise oxygen for the complete oxidation of organic food into CO_2 and water. It occurs inside the mitochondria. Aerobic respiration yields more energy as the respiratory substrate gets completely oxidised in the presence of O_2.

2. Anaerobic Respiration
This is the type of respiration in which organic food is oxidised incompletely

without utilising energy as oxidant. It occurs in cytoplasm and often releases small amount of energy.

It is believed that the first cells on this planet lived in an oxygen free environment, i.e., they were anaerobes. Even among present day living organisms, several are adapted to anaerobic conditions.

Some of them are facultative anaerobes (organisms that have capability of switching from aerobic to anaerobic conditions according to the availability of oxygen) while others are obligate anaerobes (organisms that are killed by normal atmospheric concentration of oxygen of 21%).

Thus, in any case, all living organisms retain the enzymatic machinery for partial oxidation of glucose in the absence of oxygen. And this breakdown of glucose to pyruvic acid is called glycolysis.

Topic 2 Respiration: The Mechanism

Cellular respiration occurs inside the cell and proceeds with the help of enzymes. The first step in respiration (taking glucose as substrate) is the glycolysis (glucose oxidised to pyruvic acid). After which the pyruvic acid may enter the Krebs' cycle (aerobic respiration) or undergo fermentation (anaerobic respiration).

Glycolysis
Glycolysis (Gr. Glycor-sugar; lysis-splitting), is a step-wise process by which one molecule of glucose (6C) breaks down into two molecules of pyruvic acid (3C).

The scheme of glycolysis was given by Gustav Embden, Otto Meyerhof and J Parnas and is often referred as the EMP pathway. It is a common pathway in both aerobic and anaerobic modes of respiration. But in case of anaerobic organisms, it is the only process of respiration.

Glycolysis occurs in the cytoplasm of the cell. During the process glucose gets partially oxidised. In plants this glucose is derived from sucrose (end product of photosynthesis) or from storage carbohydrates.
During the course of process in plant this sucrose is first converted into glucose

and fructose by the action of invertase enzyme after this, these two monosaccharides enter the glycolytic pathway.

Steps Involved in Glycolysis
In glycolysis, a chain of 10 reactions often reactions occur under the control of different enzymes.

It involves the following steps
Step I Phosphorylation of glucose occur under the action of an enzyme hexokinase and Mg2+ that gives rise to glucose-6-phosphate by the utilisation of ATP.

Step II Isomerisation of this phosphorylated glucose-6-phsophate takes place to form fructose-6-phosphate with the help of an enzyme phosphohexose isomerase (Reversible Reaction).

Step III This fructose-6-phosphate is again phosphorylated by ATP in order to form fructose 1, 6-bisphosphate in the presence of an enzyme phosphofructokinase and Mg^{2+}.
The steps of phosphorylation of glucose to fructose 1, 6-bisphosphate (i.e., from step 1 to 3) activates the sugar thus, preventing it from getting out of the cell.

Step IV Splitting of fructose 1, 6-bisphosphate takes place into two triose phosphate molecules, i.e., dihydroxyacetone 3-phosphate and 3-phosphoglyceraldehyde (i.e., PGAL). This reaction is catalysed by an enzyme aldolase.

Step V Each molecule of PGAL removes two redox equivalents in the form of hydrogen atom and transfer them to a molecule of NAD^+ (This NAD+ forms NADH + H^+) and accepts inorganic phosphate (Pi) from phosphoric acid. This reaction in turn leads to the conversion to PGAL (which gets oxidised) to 1, 3-bisphosphoglycerate (BPGA) (Reversible reaction).

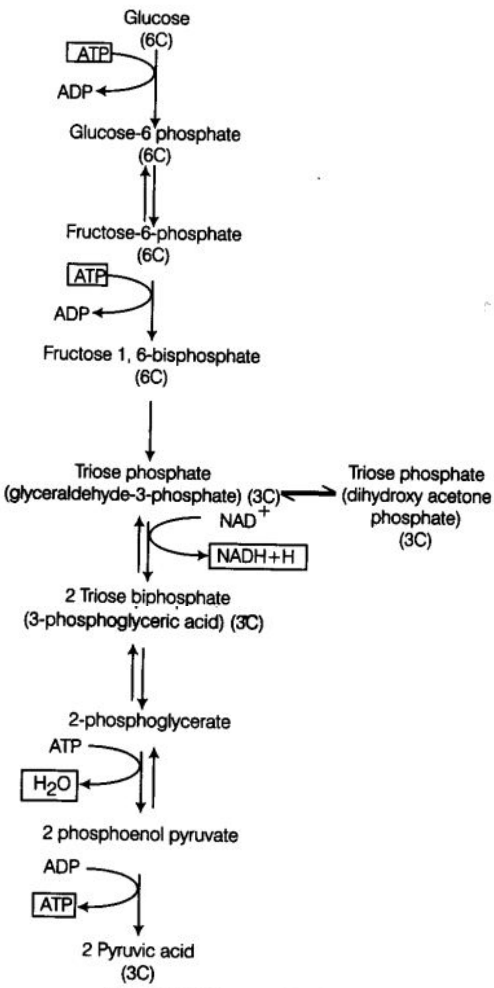


Fig 14.1 Steps of glycolysis

Step VI 1, 3-bisphosphoglycerate is converted to 3-phosphoglycerate with the formation of ATP.
This reaction is catalysed by an enzyme phosphoglycerate kinase. It is also known as energy yielding process. The formatibn of ATP directly from metabolites constitutes substrate level phosphorylation (Reversible reaction).

Step VII In the next step, 3-phosphoglycerate is subsequently isomerised to form 2-phosphoglycerate, catalysed by enzyme phosphoglyceromutase (Reversible reaction).

Step VIII In the presence of enzyme enolase and Mg^{2+}, with the loss of a water molecule, phosphoglycerate is converted to Phosphoenol Pyruvate (PEP) (Reversible reaction).

Step IX High energy phosphate group of Phosphoenol Pyruvate (PEP) is transferred to a molecule of ADP, by the action of enzyme pyruvate kinase in the presence of Mg2+ and K+ This in turn produces two molecules of pyruvic acid (pyruvate) and a molecule of ATP by substrate level phosphorylation. The pyruvic acid thus, produced is the key product of glycolysis.

Metabolic Fate of Glycolysis
The overall reaction of glycolysis can be depicted as

- Glucose + 2Pi + 2ADP + $2NAD^+$ —> 2 Pyruvate + 2ATP + 2NADH + $2H^+$
- Two molecules of NADH on oxidation produce 6 molecules of ATP. Therefore, a net gain of 8ATP molecules occurs during glycolysis.
- The fete of glycolysis depends upon the availability of oxygen in the cell. In the presence of oxygen, pyruvic acid will enter the mitochondrion and undergo complete oxidation of glucose to CO 2 andH20 in aerobic respiration (Krebs' cycle).
- On the other hand in the absence of oxygen, the pyruvic acid will undergo anaerobic respiration (lactic acid fermentation or alcoholic fermentation).

Note:

- Kostytcher (1902) coined the term anaerobic respiration.
- Glycolysis has two phases, i.e., preparatory (glucose is broken down to glyceraldehyde-3-phosphate) and pay off phase (the GAL-3-PD4 is changed into pyruvate producing NADH and ATP).

Fermentation

Various microorganisms, bacteria, animals and plants are known to catabolise pyruvic acid into various organic compounds depending upon the specific enzymes they possess.
Some of these types are as follows
(i) During alcoholic fermentation, in fungi (e.g., yeast), and some higher plants, the incomplete oxidation of glucose is achieved under anaerobic condition by a series of reactions in which pyruvic acid is converted to CO_2 and ethanol.

It is done under two steps
(a) Pyruvic acid is first decarboxylated to acetaldehyde in the presence of enzyme

pyruvic acid decarboxylase.

$$CH_3CCOOH \rightarrow \underset{\text{(acetaldehyde)}}{CH_3CHO} + CO_2$$

(b) This acetaldehyde is further reduced to ethyl alcohol or ethanol in the presence of enzyme, i.e., alcohol dehydrogenase.

$$CH_3CHO + NADH + H^+ \rightarrow \underset{\text{(ethanol)}}{C_2H_5OH} + NAD^+$$

(ii) During lactic acid fermentation, organisms like some bacteria produces lactic acid as an end product from pyruvic acid.

During the reduction, the pyruvic acid produced in glycolysis is reduced by $NADH_2$ to form lactic acid, CO_2 is not produced and $NADH_2$ is oxidised to NAD^+.

This reaction is catalysed by an lactic acid dehydrogenase, FMN proteins and Zn_2^+ ions.

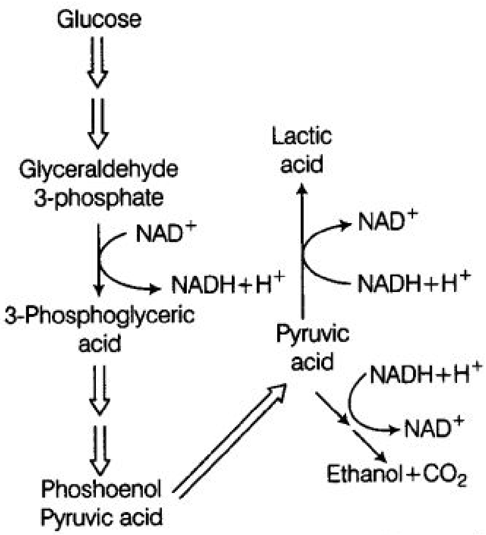


Fig 14.2 Major pathways of anaerobic respiration

Likewise, in case of animal cells also (such as muscles) during exercise, when there is inadequate amount of oxygen for cellular respiration, pyruvic acid is reduced to lactic acid by lactate dehydrogenase.
Thus, in both the processes reoxidation of reducing ($NADH + H^+$) agent takes place.

Energy Yield in Fermentation
In both alcoholic and lactic acid fermentation, the energy released is very less, i.e., not more than 7% of the energy is released from glucose and not all of it is trapped as high energy bonds of ATP.

Also, the fermentation processes are proved to be hazardous in nature because either acid or alcohol is produced on oxidation. Apart from this, yeasts may also poison themselves to death if the concentration of alcohol reaches about 13%.

Drawback of this process is that organisms cannot carryout complete oxidation of glucose and are also unable to extract out the energy stored to synthesise a larger number of ATP molecules required for cellular metabolism.

Differences between Glycolysis and Fermentation

Glycolysis	Fermentation
It is the first step of respiration which occurs without requirement of oxygen and is common to both aerobic and anaerobic mode of respiration.	It is anaerobic respiration which does not require oxygen.
It produces pyruvic acid.	Fermentation produces different products. The common ones are ethanol (and CO_2) and lactic acid.
It produces two molecules of NADH per glucose molecule.	It generally utilises NADH produced during glycolysis.
Glycolysis forms 2ATP molecules per glucose molecule.	It does not produce ATP.

Aerobic Respiration

Aerobic respiration is the next step (after glycolysis) that leads to complete oxidation of organic substances. It occurs in the presence of oxygen. The oxygen acts as a final acceptor of electron and protons are removed from the substrate. For aerobic respiration to take place within the mitochondria, the final product of glycolysis, i.e., pyruvic acid is transported into from the cytoplasm mitochondria and thus, the second phase of respiration is initiated.

The process of aerobic respiration involves two crucial events

(i) The complete oxidation of pyruvate occurs by the step-wise removal of all the hydrogen atoms, thereby, leaving three molecules of CO_2. This occurs in the matrix of mitochondria.

(ii) The electrons removed as part of the hydrogen atoms are then passed on to molecular 02 with the simultaneous synthesis of ATP. This on the contrary takes place on the inner membrane of the mitochondria.

Oxidative Decarboxylation of Pyruvic Acid

In mitochondria, pyruvic acid (formed by the glycolytic catabolism of carbohydrates in cytosol) undergoes oxidative decarboxylation (i.e., removal of CO_2 in aerobic conditions) forming a key compound, i.e., acetyl Co-A by the action of pyruvic acid dehydrogenase (in mitochondrial matrix) through a series of reactions.

$$\text{Pyruvic acid} + \text{Co-A} + NAD^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{acetyl Co-A} + CO_2 + NADH + H^+$$

Thus, acetyl Co-A acts as a connecting link between glycolysis and citric acid cycle.

During this process, two molecules of NADH are produced from the metabolism of two molecules of pyruvic acid (produced from one glucose molecule during glycolysis).
Tricarboxylic Acid (TCA) Cycle

The acetyl Co-A then enters a cyclic pathway, Krebs' cycle (or tricarboxylic acid cycle, TCA) in mitochondrial matrix. Various coenzymes including NAD^+ and Co-A also participates in the reaction catalysed by pyruvic acid dehydrogenase.

It was first elucidated by Sir Hans Kreb, a British Biochemist in 1940.
The whole cycle explains how pyruvate is broken down to CO_2 and water.

Following are the steps of Krebs ' cycle
(i) Condensation The Krebs' cycle starts with the condensation of acetyl group with oxaloacetic acid and water to yield citric acid, a 6C compound. This is the first stable product of the cycle.
This step is catalysed by an enzyme citrate synthetase. Co-A is liberated during this reaction.

(ii) Citric acid then undergoes reorganisation in two steps in order to form in the presence of an enzyme acinotase. intermediate

(iii) Oxidative decarboxylation Isocitrate is followed by two successive steps of oxidative decarboxylation, that leads to the formation of a-ketoglutaric acid, (a 5C compound in the presence of an enzyme isocitrate dehydrogenase and Mn1) and then succinyl Co-A, catalysed by a-complex. .

The succinyl Co-A then splits into a 4C compound succinic acid and Co-A with the addition of water. During this conversion, a molecule of GTP (guanosine triphosphate) is synthesised catalysed by an enzyme succinyl Co-A synthetase (this occurs when co-enzyme A transfers its high energy to a phosphate group that joins GDP forming GTP).
(i) GTP is also an energy carrier like ATP. Thus, this is the only high energy phosphate produced in the Krebs' cycle.

(ii) In plants cells, this reaction also produces ATP from ADP.
In the remaining steps of Krebs' cycle, succinyl Co-A is oxidised to oxaloacetic acid, a 4C compound following the formation of fumaric acid and malic acid catalysed by enzymes succinate dehydrogenase and fumacase respectively.

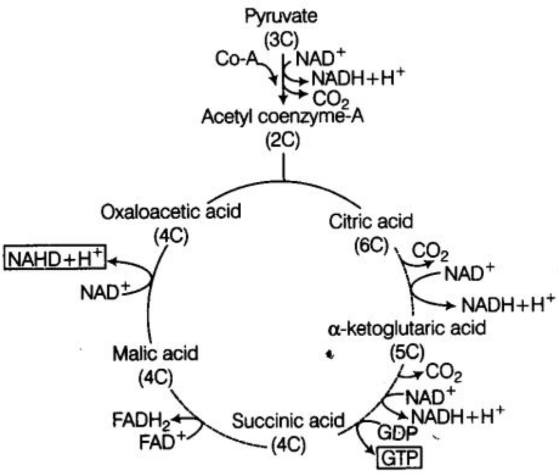


Fig 14.3 The citric acid cycle

Output of Krebs' Cycle or Citric Acid Cycle
During this cycle of reactions, 3 molecules of NAD^+ are reduced to NADH + H^+, and one molecule of FAD^+ is reduced to $FADH_2$. And also one molecule of ATP is reduced directly from GTP (by substrate level phosphorylation).
For continuous oxidation of acetyl Co-A, continued replenishment of oxaloacetic acid is necessary. In addition to this regeneration of NAD^+ and FAD^+ from NADH and $FADH_2$ respectively are also required.

The summary equation for this phase of respiration is as follows

$$\text{Pyruvic acid} + 4NAD + FAD^+ + 2H_2O + ADP + Pi \xrightarrow{\text{Mitochondrial Matrix}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

Till now, glucose has been broken down to release CO_2 and 8 molecules of NADH+H^+, two $FADH_2$ are synthesised and just two molecules of ATP.

Importance of Citric Acid Cycle

The citric acid cycle is important in thefollowing ways
(i) This is the major pathway for the formation for ATP molecules.
(ii) Many intermediate compounds of this cycle are used in the synthesis of other biomolecules.

Differences between glycolysis and Krebs'cycle

Glycolysis	Krebs' Cycle
It takes place in the cytoplasm.	It takes place in the matrix of mitochondria.
It is a linear pathway.	It is a cyclic pathway.
It occurs in aerobic as well as anaerobic respiration.	It occurs in aerobic respiration only.
It consumes 2 ATP molecules.	It does not consume ATP.
It yields 2 NADH per glucose molecule.	It yields 6 NADH molecules and 2 $FADH_2$ molecules from 2 acetyl coenzyme-A molecules.
It generates 2 ATP molecules net from 1 glucose molecule.	It generates 2 GTP/ATP molecules from 2 acetyl coenzyme-A molecules.
It oxidises glucose partly, producing pyruvate.	It oxidises acetyl coenzyme-A fully.
It does not produce CO_2.	It produces CO_2.
All enzymes catalysing glycolytic reactions are dissolved in cytosol.	Two enzymes of Krebs' cycle reactions are located in the inner mitochondrial membrane, all others are dissolved in matrix.

Respiration in Plants Class 11 MCQs Questions with Answers
Question 1.
R.Q is ratio of
(a) CO_2 produced to substarate consumed
(b) CO_2 produced to O_2 consumed
(c) oxygen consumed to CO_2 produced
(d) oxygen consumed to water produced
Answer
Answer: (b) CO_2 produced to O_2 consumed
Question 2.
Angiosperm pollen is generally released at the
(a) 1 – celled stage
(b) 2 – celled stage
(c) 3 – celled stage
(d) male gamete formation stage
Answer

Answer: (b) 2 – celled stage
Question 3.
The complete oxidation of pyruvate take place in
(a) cell cytoplasm
(b) inner mitochondrial membrane
(c) mitochondrial matrix
(d) nucleus
Answer
Answer: (c) mitochondrial matrix
Explanation:
Pyruvate is transported from cytoplasm into the mitochondria. The complete oxidation of pyruvate takes place in matrix of mitochondria.
Question 4.
Which enzyme catalyses the reaction below? Pyruvic acid → Carbon dioxide + Ethanol
(a) Pyruvic acid decarboxylase
(b) Alcohol dehydrogenase
(c) None of these
(d) Both of these
Answer
Answer: (d) Both of these
Explanation:
In fermentation, the incomplete oxidation of glucose is achieved under anaerobic conditions by sets of reactions in which pyruvic acid is converted to carbon dioxide and ethanol.
The enzymes involved are pyruvic acid decarboxylase and alcohol dehydrogenase.
Question 5.
TCA cycle was discovered by
(a) Otto Meyerhof
(b) Hans Kreb
(c) Gustav Embden
(d) All of these
Answer
Answer: (b) Hans Kreb
Explanation:
TCA cycle or tricarboxylic acid cycle was given by Hans Kreb. So it is also called as Kreb cycle.
Question 6.
Which one of the following describes the spikelet of a cereal or grass plant
(a) inferior ovary
(b) dehiscent fruit
(c) pair of glumes
(d) fused calyx

Answer
Answer: (c) pair of glumes
Question 7.
Malacophily means
(a) pollination by wind
(b) pollination by water
(c) pollination by insects
(d) pollination by snails
Answer
Answer: (d) pollination by snails
Question 8.
Herkogamy is a contrivance for
(a) allogamy
(b) autogamy
(c) chasmogamy
(d) cleistogamy
Answer
Answer: (a) allogamy
Question 9.
Out of 36 ATP molecules produced per glucose molecule during respiration
(a) 2 are produced outside glycolysis and 34 during repiratory chain
(b) 2 are produced outside mitochondria and 34 inside the mitochondria
(c) all the formed inside mitochondria
(d) 2 during glycolysis and 34 during kreds cycle
Answer
Answer: (b) 2 are produced outside mitochondria and 34 inside the mitochondria
Question 10.
Complete the reaction. __________ + $O_2 \rightarrow CO_2$ + ________ + Energy
(a) $C_6H_{12}O_6$, $2H_2O$
(b) $C_{12}H_{22}O_{11}$, $6H_2O$
(c) $C_6H_{12}O_6$, $6H_2O$
(d) $C_{12}H_{22}O_{11}$, $11H_2O$
Answer
Answer: (c) $C_6H_{12}O_6$, $6H_2O$
Explanation:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy
Question 11.
The significant morphological feature of passion flower is the presence of
(a) numerous corolla
(b) androphore
(c) gynophore
(d) androgynophore

Answer
Answer: (b) androphore
Question 12.
The final electron acceptor in electron transport chain is
(a) Cytochrome C
(b) FADH
(c) NADH
(d) oxygen
Answer
Answer: (d) oxygen
Explanation:
Oxygen acts as the final electron acceptor in electron transport chain.
Question 13.
Which of the following acts as mobile carrier for transfer of electrons between complex III and complex IV?
(a) Cytochrome c
(b) cytochrome a3
(c) cytochrome a
(d) $FADH_2$
Answer
Answer: (a) Cytochrome c
Explanation:
Cytochrome c is a small protein attached to outer surface of the inner membrane and acts as mobile carrier for transfer of electrons between complex III and IV.
Question 14.
Aleurone layer takes part in
(a) protection of delicate embryo
(b) enzyme synthesis
(c) transfer of food to cotyledons
(d) transfer of food from cotyledons to embryo tips
Answer
Answer: (b) enzyme synthesis
Question 15.
A characteristic of drupe is
(a) fleshy seed coat
(b) stony pericarp
(c) stony mesocarp
(d) stony endocarp
Answer
Answer: (d) stony endocarp
Question 16.
Incomplete oxidation of glucose into pyruvic acid with several intermediate steps is know

as
(a) TCA pathway
(b) Glycolysis
(c) Hms pathway
(d) Glycolysis
Answer
Answer: (b) Glycolysis
Question 17.
End product of glycolysis is
(a) acetyl Coenzyme A
(b) PEP
(c) pyruvate
(d) OAA
Answer
Answer: (c) pyruvate
Explanation:
The end product of glycolysis is pyruvate.
Question 18.
Respiratory enzymes are located in
(a) mitochondrial matrix
(b) Cristae
(c) perimitochondrial space
(d) outer membrane
Answer
Answer: (b) Cristae
Question 19.
Respiratory quotient of carbohydrates is
(a) 0.9
(b) 1.2
(c) 1
(d) 0
Answer
Answer: (c) 1
Explanation:
RQ i.e. respiratory quotient is 1.
RQ = volume of CO_2 evolved / volume of O_2 consumed
Question 20.
One molecule of glucose yields ___ ATP molecules in aerobic respiration.
(a) 2
(b) 16
(c) 38
(d) 42

Answer
Answer: (c) 38
Explanation:
One molecule of glucose yields 38 molecules of ATP during aerobic respiration.

Solutions for Class 11 Biology Chapter 14 Respiration in Plants:

Section Name	**Topic Name**
14	Respiration in Plants
14.1	Do Plants Breathe?
14.2	Glycolysis
14.3	Fermentation
14.4	Aerobic Respiration
14.5	The Respiratory Balance Sheet
14.6	Amphibolic Pathway
14.7	Respiratory Quotient
14.8	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1. Give the schematic representation of an overall view of Krebs' cycle.

Solution:

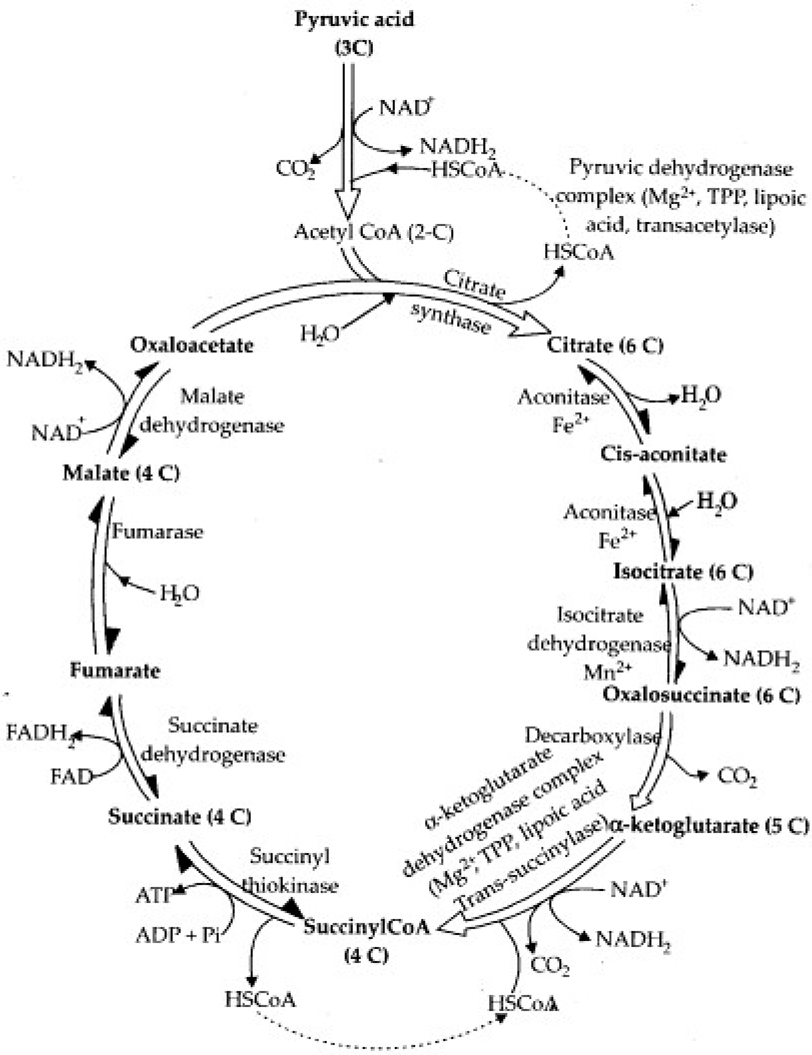


Fig.: Schematic representation of Krebs' cycle

2. Differentiate between

(a) Respiration and Combustion

(b) Glycolysis and Krebs'cycle

(c) Aerobic respiration and Fermentation

Solution: (a) Differences between respiration and combustion are as follows :

	Respiration	Combustion
(i)	It occurs inside living cells.	It is a noncellular process.
(ii)	Respiration is a biochemical process.	Combustion is a physio-chemical process.
(iii)	Energy is released in stages as chemical bonds are broken in steps.	Energy is released in a single step as all chemical steps occur simultaneously.
(iv)	Most of the energy is trapped in ATP molecules.	ATP is not formed.
(v)	Oxidation occurs at the end of reaction (terminal oxidation) between reduced coenzymes and oxygen.	The substrate is directly oxidised in combustion.
(vi)	A number of intermediates are formed. They are used in the synthesis of different organic compounds	No intermediates are produced in combustion.
(vii)	A number of enzymes are required, one for each step or reaction.	Burning is a non-enzymatic process.
(viii)	Less than 50% energy is liberated in the form of heat energy. Light is rarely produced.	Energy is libreated in the form of both light and heat energy.
(ix)	Temperature is not allowed to rise.	Temperature becomes very high.

(b) Differences between glycolysis and Krebs' cycle are as follows:

	Glycolysis	Krebs' cycle
(i)	It occurs inside the cytoplasm.	Krebs' cycle operates inside mitochondria.
(ii)	Glycolysis is the first step of respiration in which glucose is broken down to the level of pyruvate.	Krebs' cycle is the second step in respiration where an active acetyl group is broken down completely.
(iii)	The process is common to both aerobic and anaerobic modes of respiration.	It occurs only in aerobic respiration.
(iv)	It degrades a molecule of glucose into two molecules of an organic substance, pyruvate.	It degrades pyruvate completely into inorganic substances ($CO_2 + H_2O$).
(v)	Glycolysis consumes 2 ATP molecules for the initial phosphorylation of substrate molecule.	It does not consume ATP.

(vi)	In glycolysis, one glucose molecule liberates 4 ATP molecules through substrate level phosphorylation.	In Krebs' cycle, two acetyl residues liberate two ATP or GTP molecules through substrate level phosphorylation.
(vii)	Net gain is two molecules of NADH and two molecules of ATP for every molecule of glucose broken down.	Krebs' cycle produces six molecules of NADH, and 2 molecules of $FADH_2$ for every two molecules of acetyl CoA oxidised by it. Two molecules of NADH are liberated during conversion of two pyruvates to acetyl CoA.
(viii)	The net gain of energy is equal to 8 ATP.	The net gain of energy is equal to 24 molecules of ATP. Six molecules of ATP can be produced from $2NADH_2$ formed during dehydrogenation of two pyruvates.
(ix)	No carbon dioxide is evolved in glycolysis.	Carbon dioxide is evolved in Krebs' cycle.
(x)	Oxygen is not required for glycolysis.	Krebs' cycle uses oxygen as terminal oxidant.

(C)Differences between aerobic respiration and fermentation are as follows:

	Aerobic respiration	Fermentation
(i)	It uses oxygen for breaking the respiratory material into simpler substances.	Oxygen is not used in the breakdown of respiratory substrate.
(ii)	Respiratory material is completely oxidised.	Respiratory material is incompletely broken.
(iii)	The end products are inorganic.	At least one of the end products is organic. Inorganic substances may or may not be produced.
(iv)	Aerobic respiration is the normal mode of respiration of plants and animals.	It is the normal mode of respiration in some parasitic worms and microorganisms. In others, anaerobic respiration is a stop-gap arrangement.
(v)	Aerobic respiration consists of three steps –glycolysis, Krebs' cycle and terminal oxidation.	Anaerobic respiration or fermentation consists of two steps – glycolysis and incomplete breakdown of pyruvic acid.
(vi)	Every carbon atom of the food is oxidised and a large quantity of carbon dioxide is evolved.	Less quantity of carbon dioxide is evolved.
(vii)	Water is formed.	Water is usually not formed.
(viii)	686 kcal of energy are produced per gm mole of glucose.	Only 39-59 kcal of energy are formed per gm mole of glucose.
(ix)	It continues indefinitely.	It cannot continue indefinitely (except in some micro-organisms) because of the accumulation of poisonous compounds and less availability of energy per gm mole of food broken.

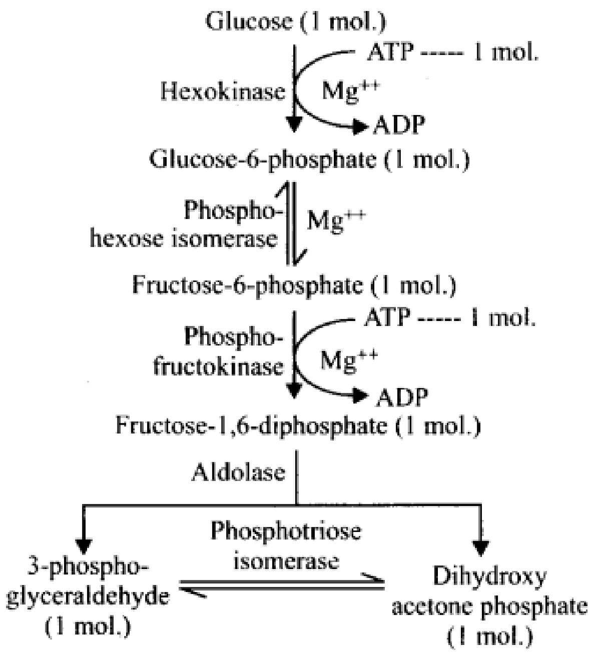
More Resources for CBSE Class 11

3. What are respiratory substrates? Name the most common respiratory substrate.

Solution: Respiratory substrates are those organic substances which are oxidised during respiration to liberate energy inside the living cells. The common respiratory substrates are carbohydrates, proteins, fats and organic acids. The most common respiratory substrate is glucose. It is a hexose monosaccharide.

4. Give the schematic representation of glycolysis.

Solution:



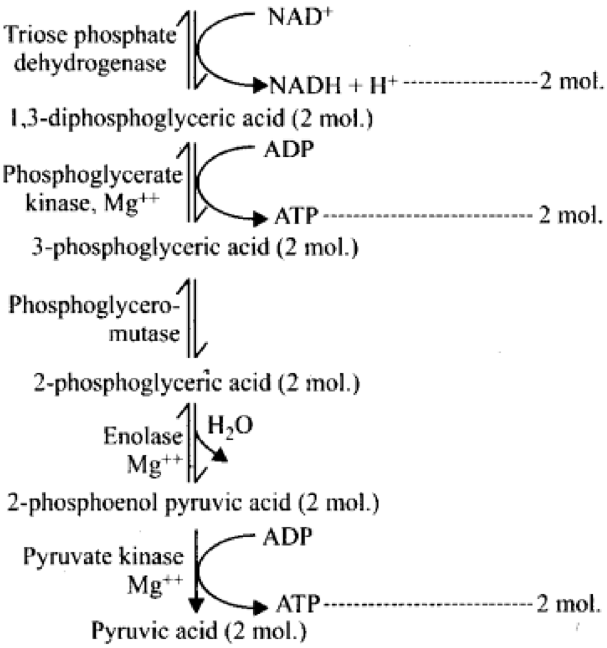


Fig.: Glycolysis or EMP-pathway.

5. Explain ETS.

Solution: An electron transport chain or system (ETS) is a series of coenzymes and cytochromes that take part in the passage of electrons from a chemical to its ultimate acceptor. Reduced coenzymes participate in electron transport chain. Electron transport takes place on cristae of mitochondria [oxysomes (F_0 -F_1 , particles) found on the inner surface of the membrane of mitochondria]. NADH formed in glycolysis and citric acid cycle are oxidised by NADH dehydrogenase (complex I) and the electrons are transferred to ubiquinone. Ubiquinone also receives reducing equivalents via FADH2 through the activity of succinate dehydrogenase (complex II). The reduced ubiquinone is then oxidised by transfer of electrons of cytochrome c via cytochrome Fc, complex (complex III). Cytochrome c acts as a mobile carrier between complex III and complex IV. Complex IV refers to cytochrome c oxidase complex containing cytochromes a and $a_3$and two copper centres. When the electrons are shunted over the carriers via complex I to IV in the electron transport chain, they are coupled to ATP synthetase (complex V) for the formation of ATP from ADP and Pi. Oxygen functions as the terminal acceptor of electrons and is reduced to water along with the hydrogen atoms. Reduced coenzymes (coenzyme I, II and FAD) do not combine directly with the molecular O_2. Only their hydrogen or electrons are transferred through various substances and finally reach O_2. The substances useful for the transfer of electron are called electron carriers. Only electrons are transferred through cytochromes (Cyt F_1 Cyt c,,C_2, a, a_3) and finally reach molecular O_2. Both cytochrome a and a3 form a system called cytochrome oxidase. Copper is also present in Cyt a_3 in addition to iron. The molecular oxygen that has accepted electrons now receives the protons that were liberated into the surrounding medium to give rise to a molecule of water. The liberated energy is utilised for the synthesis of ATP from ADP and Pi.

6. What are the main steps in aerobic respiration? Where does it take place?

Solution: Aerobic respiration is an enzymatically controlled release of energy in a stepwise catabolic process of complete oxidation of organic food into carbon dioxide and water with oxygen acting as terminal oxidant. It
occurs by two methods, common pathway and pentose phosphate pathway. Common pathway is known so because its first step, called glycolysis, is common to both aerobic and anaerobic modes of respiration. The common pathway of aerobic respiration consists of three steps – glycolysis, Krebs' cycle and terminal oxidation. Aerobic respiration takes place within mitochondria. The final product of glycolysis, pyruvate is transported from the cytoplasm into the mitochondria.

7. What are the assumptions made during the calculation of net gain of ATP?

Solution: It is possible to make calculations of the net gain of ATP for every glucose molecule oxidised; but in reality this can remain only a theoretical exercise. These calculations can be made only on certain assumptions that:

- There is a sequential, orderly pathway functioning, with one substrate forming the next and with glycolysis, TCA cycle and ETS pathway following one after another.
  transferred into the mitochondria and undergoes oxidative phosphorylation.
- None of the intermediates in the pathway are utilised to synthesise any other compound.
- Only glucose is being respired – no other alternative substrates are entering in the pathway at any of the intermediary stages.

But these kind of assumptions are not really valid in a living system; all pathway work simultaneously and do not take place one after another; substrates enter the pathways and are withdrawn from it as and when necessary; ATP is utilised as and when needed; enzymatic rates are controlled by multiple means. Hence, there can be a net gain of 36 ATP molecules during aerobic respiration of one molecule of glucose.

8. Distinguish between the following:
(a) Aerobic respiration and Anaerobic respira¬tion.
(b) Glycolysis and Fermentation.
(c) Glycolysis and Citric acid cycle.

Solution: (a) Differences between aerobic and anaerobic respiration are as follows:

Aerobic respiration	Anaerobic respiration
Aerobic respiration is a type of respiration in which foodstuffs (usually carbohydrates) are completely oxidised to carbon dioxide and water, with the release of chemical energy, in a process requiring atmospheric oxygen. The reaction can be summarized by the equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$	Anaerobic respiration is a type of respiration in which foodstuffs (usually carbohydrates) are partially oxidised, with the release of chemical energy, in a process not involving atmospheric oxygen. Since the substrate is never completely oxidised the energy yield of this type of respiration is lower than that of aerobic respiration. It occurs in some yeasts and bacteria and in muscle tissue when oxygen is absent.

(b) Differences between glycolysis and fermentation are as follows:

	Glycolysis	Fermentation
(i)	It is the first step of respiration which occurs without requirement of oxygen and is common to both aerobic and anaerobic modes of respiration.	It is anaerobic respiration or respiration which does not require oxygen.
(ii)	Glycolysis produces pyruvic acid.	Fermentation produces different products. The common ones are ethanol (and CO_2) and lactic acid.
(iii)	It produces two molecules of NADH per glucose molecule.	It generally utilises NADH produced during glycolysis.
(iv)	It forms 2 ATP molecules per glucose molecule.	It does not produce ATP.

9. Discuss "The respiratory pathway is an amphibolic pathway".

Solution: Amphibolic pathway is the one which is used for both breakdown (catabolism) and build-up (anabolism) reactions. Respiratory pathway is mainly a catabolic process which serves to run the living system by providing energy. The pathway produces a number of intermediates. Many of them are raw materials for building up both primary and secondary metabolites. Acetyl CoA is helpful not only in Krebs' cycle but is also raw material for synthesis of fatty acids, steroids, terpenes, aromatic compounds and carotenoids, a-ketoglutarate is organic acid which forms glutamate (an important amino acid) on amination. OAA (Oxaloacetic acid) on amination produces asparate. Both aspartate and glutamate are components of proteins. Pyrimidines and alkaloids are other products. Succinyl CoA

forms cytochromes and chlorophyll.
Hence, fatty acids would be broken down to acetyl CoA before entering the respiratory pathway when it is used as a substrate. But when the organism needs to synthesise fatty acids, acetyl CoA would be withdrawn from the respiratory pathway for it. Hence, the respiratory pathway comes into the picture both during breakdown and synthesis of fatty acids. Similarly, during breakdown and synthesis of proteins too, respiratory intermediates form the link. Breaking down processes within the living organism is catabolism, and synthesis is anabolism. Because the respiratory pathway is involved in both anabolism and catabolism, it would hence be better to consider the respiratory pathway as an amphibolic pathway rather than as a catabolic one.

10. Define RQ. What is its value for fats?

Solution: Respiratory quotient (RQ) is the ratio of the volume of carbon dioxide produced to the volume of oxygen consumed in respiration over a period of time. Its value can be one, zero, more than 1 or less than one.

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

Volume of C02 evolved Volume of 02 consumed
RQ is less than one when the respiratory substrate is either fat or protein.
$C_{57}H_{104}O_6 + 80\ O_2 \rightarrow 57\ CO_2 + 52H_2O$
$RQ = 57CO_2/80O_2 = 0.71$
RQ is about 0.7 for most of the common fats.

11. What is oxidative phosphorylation?

Solution: Oxidative phosphorylation is the synthesis of energy rich ATP molecules with the help of energy liberated during oxidation of reduced co-enzymes (NADH, $FADH_2$) produced in respiration. The enzyme required for this synthesis is called ATP synthase. It is considered to be the fifth complex of electron transport chain. ATP synthase is located in FT or head piece of F_0 -F_1 or elementary particles. The particles are present in the inner mitochondrial membrane. ATP synthase becomes active in ATP formation only where there is a proton gradient having higher concentration of H^+ or protons on the F_0 side as compared to F x side (chemiosmotic hypothesis of Peter Mitchell).
Increased proton concentration is produced in the outer chamber or outer surface of inner mitochondrial membrane by the pushing of proton with the help of energy liberated by passage of electrons from one carrier to another. Transport of the

electrons from NADH over ETC helps in pushing three pairs of protons to the outer chamber while two pairs of protons are sent outwardly during electron flow from $FADH_2$. The flow of protons through the F_0 channel induces F_1 particle to function as ATP-synthase. The energy of the proton gradient is used in attaching a phosphate radical to ADP by high energy bond. This produces ATP. Oxidation of one molecule of $NADH_2$ produces 3 ATP molecules while a similar oxidation of $FADH_2$ forms 2 ATP molecules.

12. What is the significance of step-wise release of energy in respiration?

Solution: The utility of step-wise release of energy in respiration are given as follows :

(i) There is a step-wise release of chemical bond energy which is very easily trapped in forming ATP molecules.
(ii) Cellular temperature is not allowed to rise.
(iii) Wastage of energy is reduced.
(iv) There are several intermediates which can be used in production of a number of biochemicals.
(v) Through their metabolic intermediates different substances can undergo respiratory catabolism.
(vi) Each step of respiration is controlled by its own enzyme. The activity of different enzymes can be enhanced or inhibited by specific compounds.
This helps in controlling the rate of respiration and the amount of energy liberated by it.

Plant Growth and Development Class 11 Notes Biology Chapter 15

All plant organs are made up of various kinds of tissues which occupy specific locations within an organ and perform specific designated functions. Thus, the development of a plant follows a very precise pattern, during this period complex body organisation is formed, i.e., produces, roots, leaves, branches, flowers, fruits, seed which finally dies.

Topic 1 Growth, Differentiation and Development

The life of a plant initiates from a single cell called zygote. All the structures of plants such as roots, stems, leaves, flowers, fruits and seeds arise from a single cell in a very orderly sequence.

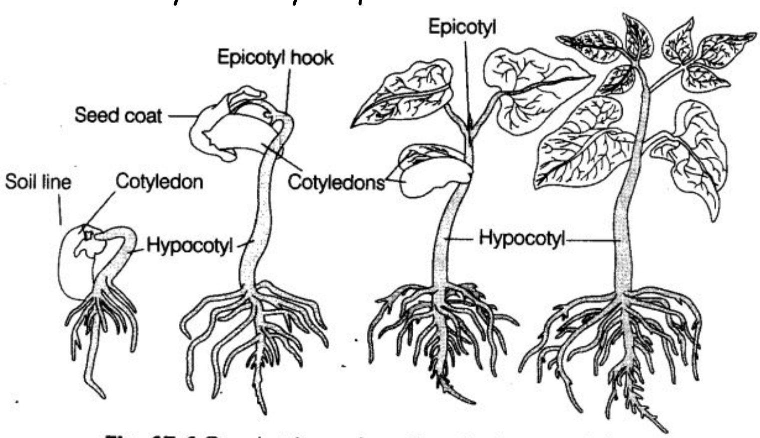


Fig. 15.1 Germination and seedling development in bean

Growth
It is regarded as an essential, fundamental and one of the most conspicuous characteristics of a living being. Growth can be defined as a dynamic, irreversible permanent increase in size of an organ, its parts or even an individual cell.
The growth is generally accompanied by the metabolic processes, i.e.„ anabolic and catabolic reactions occurring in an organism (mainly protein synthesis). Thus,

growth in living organism is an intrinsic phenomenon (unlike, non-living organisms in which growth is extrinsic).

Plant Growth Generally is Indeterminate
Growth of plant is unique as they retain the capacity for unlimited growth throughout their life. In plants the growth is generally confined only to the meristematic tissues present at certain locations in the body. Meristems in the plant have certain cells that have the capacity of dividing and self-perpetuation.

The new cells produced by the action of division of meristematic cells, soon loose, the ability of dividing and make up the plant frody.

The form of growth in which newly producing cells are always being added to the body erf the plant by the activity of meristems is called open form of growth.

If the meristem ever ceases to divide, the growth of I the plant will not occur and they may undergo a j period of dormancy depending upon the seasonal j changes in the climate.

Regions of Growth
Apical, lateral and intercalary are the special regions, where growth is localised in plants.
At the apex of every root and shoot apical meristems are present which are responsible for the elongation of plant along their axis. This is known as primary growth of the plant.

Note:
A meristematic tissue consists of a group of cells, which remain in active and continuous state of division, and they retain their power of division. It consists of immature, living,
thin-walled cells, which are rich in cytoplasm.

In the mature plant, meristem is also found in intercalary and lateral regions. .
The lateral meristems, vascular cambium and cork cambium appear later in life in dicotyledonous plants and gymnosperms and are responsible for the increase in the girth of the stem. This increase in girth is known as secondary growth of the plant.

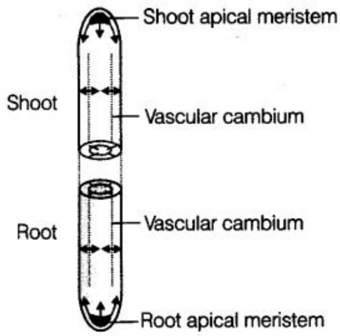


Fig. 15.2 Diagrammatic representation of locations of root apical meristem, shoot apical meristem and vascular cambium. Arrows exhibit the direction of growth of cells and organ

Growth is Measurable

As stated that at cellular level, growth is the consequence of increase in the amount of protoplasm. It is difficult to measure the increase in the protoplasm directly, so it can generally be measured by measuring some quantity of it that is more or less proportional to it.

Hence, growth can be easily measured by a variety of parameters such as

(i) Dry weight (ii) Fresh weight
(iii) Length (iv) Area
(v) Volume (vi) Cell number

Growth can be expressed in terms of increase in the cell number, e.g., Single root apical meristem in maize which give rise to more than 17,500 new cells per hour.

It can also be expressed as an increase in the size of the cell, e.g., Cells in watermelon increases about 3,50,000 times per hour.

Growth can be measured in terms of its length, e.g., Pollen tube and can also be measured in terms of surface area, e.g., In a dorsiventral leaf.

Phases of Growth

Under favourable conditions, growth of plant shows a characteristic course. The period of growth is generally divided into three phases.
All three phases can be easily understood by taking the example of root tip.

i. Meristematic Phase

The cells that are constandy dividing, i.e., both at the apex of the root and shoot represents the meristematic phase of growth.

Features shown by this phase are

- rich in protoplasm.
- has large conspicuous nuclei.
- cell walls are primary in nature.
- a thin, cellulosic, has plasmodesmatal connections.

This phase is also known as division phase.

ii. Elongation Phase
This phase lies just behind the growing parts, i.e., behind the meristematic zones away from the tip.

Features shown by this phase are

- increased vacuolation.
- enlargement of cell.
- deposition of new cell wall.

Enlargement of cell during this phase occurs in all direction. Maximum elongation is seen in conducting tissues and fibres.

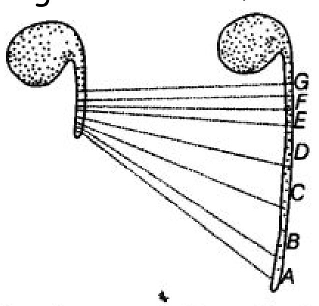


Fig. 15.3 Detection of zones of elongation by the parallel line technique. Zones *A, B, C, D* immediately behind the apex have elongated most

iii. Maturation Phase
Just behind the phase of elongation, occurs a phase of maturation. It occurs further away from the apex, i.e., more proximal to the elongation phase.

Features shown by this phase are

- cells attain maximum thickening of their wall.
- protoplasmic modifications are maximum.

Growth Rate

The growth rate is defined as the increased growth per unit time. Rate of growth can be expressed mathematically. It shows increase that may be arithmetic or geometrical in nature.

i. Arithmetic Growth

Somatic cells increases in number due to mitosis. In this type of growth, following mitotic cell division, only one daughter cell continues to divide, while others follow differentiation and attains maturity.

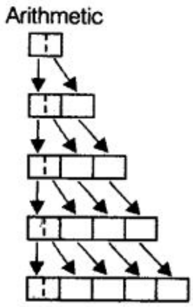


Fig. 15.4 Diagrammatic representation of arithmetic growth

Expression of arithmetic growth can be exemplified by a root elongating at a constant rate. A linear curve is obtained on plotting the length of root against time.

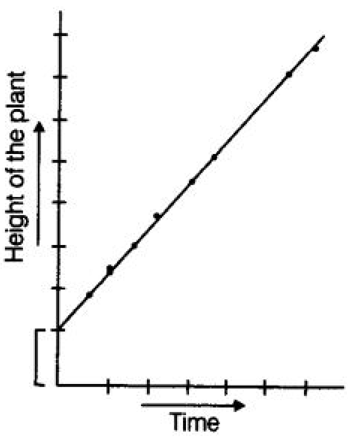


Fig. 15.5 Constant linear growth, a plot of length L against time t

$$L_t = L_0 + rt$$

where L_t = Length at time 't'

L_0 = Length at time 'zero'

and r = Growth rate/elongation per unit time.

ii. Geometrical Growth

In living organisms, during geometric type of growth rate, pattern follows three important phases

(a) Lag Phase (initial or the beginning phase) It is mainly characterised by very slow growth.

(b) Log Phase (exponential phase) It is the middle phase of the system and is characterised by very fast and rapid growth of the plant body. After initiation of growth, it increases rapidly at an exponential rate.

During this phase, both progeny cells undergoing mitotic cell division retain the ability to divide and continue dividing till the next phase appears till the time nutrient supply is appropriate.

(c) Stationary Phase (steady phase) This phase occurs when either the plant reaches maturity or the supply of nutrients become limited. Due to these mentioned factors, the growth of the plant slows down to come to a halt.

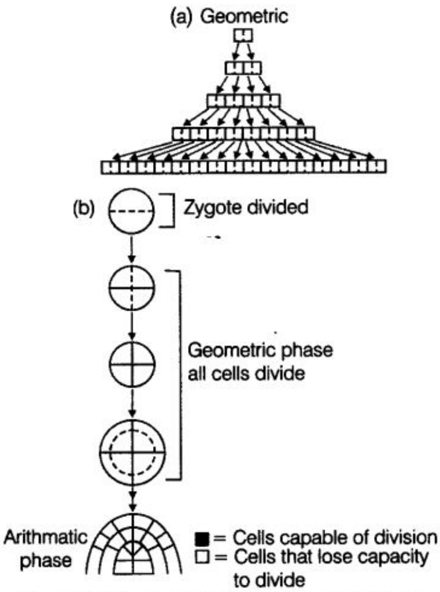


Fig. 15.6 Diagrammatic representation of (a) Geometric growth and (b) Stages during empryo development showing geometric and arithmatic phases

Under favorable conditions, the characteristic course of growth is observed. Thus, if we plot the parameter of growth rate against time, the typical shaped, a sigmoid curve is seen.

It shows a characteristic feature of all living organism growing in a natural environment. This curve is typical for all cells, tissues and organs of a plant.

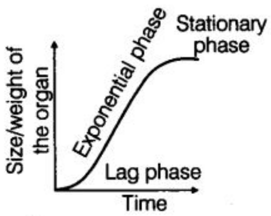


Fig. 15.7 An Ideal sigmoid growth curve typical of cells in culture and many higher plants and plant organs

The exponential growth can be expressed as

$$W_1 = W_0 e^{rt}$$

where, W_1 = Final size (weight, height, number, etc.)
W_0 = Initial size at the beginning of the period
t = Time of growth
e = Base of natural logarithms

and, r — relative growth rate that measures the ability of the plant to produce new plant material, known as efficiency index.
The final size (W_1) depends on the initial size (W_0).

Quantitative Comparisons of Growth Rate

The quantitative comparisons between the growth of living systems is done in following two ways

i. Absolute Growth Rate

It is known to be the measurement and comparison of total growth per unit time.

ii. Relative Growth Rate

It is the growth of the given system per unit time expressed on a common basis, e.g., Per unit initial parameter.

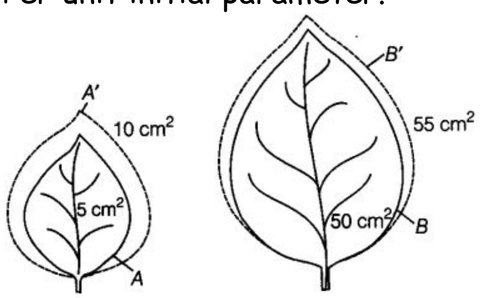


Fig. 15.8 Diagrammatic comparison of absolute and relative growth rate. Both leaves *A* and *B* have increased their area by 5 cm² in a given time to produce *A'* *B'* leaves.

Leaves A and B shown in the figure have grown 5 cm^2 in one day. Although their sizes are different, i.e., 5 cm^2 and 50 cm_2 respectively but both of them shows absolute increase in area in the given time to give leaves A and B, i.e., 5 cm^2 in both cases. Out of these two the relative growth rate is higher or faster in leaf A.

Conditions or Factors for Growth
The growth of a plant is influenced by a variety of external and internal factors. Growth of plant involves synthesis of protoplasm, cell division, cell enlargement and cell differentiation.

Some of the factors due to which growth of plants is influenced are mentioned below
i. Water
It is the first and the foremost requirement of the plants for the enlargement of cell, maintaining turgidity of growing cells, for extension of growth. It also acts as a medium for many enzymatic activities. In water stress conditions growth of the plants seems to get retarded.

ii. Oxygen
It helps in releasing metabolic energy essential for growth activities.

iii. Nutrients
These acts as (macro and micro essential nutrients) major raw materials for protoplasmic synthesis and also acts as a source of energy. However, under nutrient deficient conditions the growth of the plant is affected.
Details of each and every essential nutrient has already been studied in chapter 12.

iv. Light
The requirement of the light to the plants for its growth is called photo-periodism. It helps in synthesis of food. It also determines the root and shoot growth. Along with light, gravity also serves as art environmental signal that affects certain phases/stages of growth.

v. Temperature
For normal and appropriate growth of plant optimum temperature range is necessary, i.e., 25-30°C (this happens because enzymatic reactions are very fast at optimum temperature range).

Differentiation, Dedifferentiation and Redifferentiation
Differentiation
During growth, meristematic cell divides by mitotic division to form daughter cells. The cells from root and shoot apical meristem, cambium or other meristems tends to differentiate and mature to perform specific functions. This act leading to maturation is known as differentiation.

e.g., Cell tends to loose their protoplasm, in order to form tracheary element. These cells also develop a very strong, elastic, lignocellulosic secondary cell wall in order to carryout water to long distance even under extreme conditions.

Dedifferentiation
The living differentiated cells also show another interesting phenomenon during which they regain the capacity to divide mitotically under certain conditions. The dedifferentiated cell can act as a meristem, e.g., Formation of meristems-interfasicular cambium and cork cambium from fully differentiated parenchyma cells.

Redifferentiation
The products of dedifferentiated.cells or tissue when lose the capacity to divide but mature taperform specific functions is known as redifferentiation, e.g, Secondary cortex and cork.
Parenchyma cells that are made to divide to form callus under controlled laboratory conditions are examples of dedifferentiated tissue. From the above discussion, it is very much clear that growth in plants is open in spite of differentiation shown by them.

It is so because cells/tissue that arise out of the single or same meristem shows different structures after attaining maturity. Thus, the final structure at maturity of a cell/tissue arising from the same tissue is also determined by the location of the cells, e.g, Cells positioned away from the root apical meristems differentiate as root cap cells, while those which are pushed to the periphery develops and matures as epidermis.

Development
It is the process that includes a series of changes that an organism goes through during its life cycle, i.e., from germination till senescence.

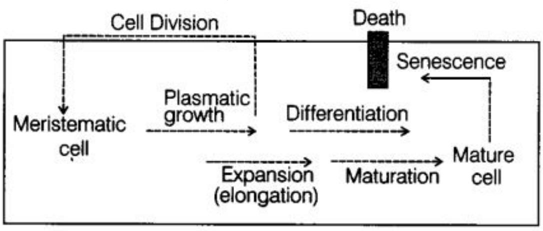


Fig. 15.9 Sequence of the developmental process in a plant cell

In broad terms development is the sum total of both growth and differentiation in plants.

The developmental process, of growth and differentiation is controlled by several intrinsic and extrinsic factors
(i) Intrinsic factors includes, both intracellular (genetic) or intercellular factors (such as plant growth regulators).
(ii) Extrinsic factors includes, light, temperature, water, oxygen, nutrition, etc.

Plasticity
Plasticity refers to a phenomenon in which plants follows different pathways in response to environment or phases of life forming different kinds of structures, e.g., Heterophylly, the phenomenon in plants by which more than two types of leaves occurs on the same plant.

Topic 2 Plant Growth Regulators

It has been suggested from sufficient evidences that the plants have certain chemical substances, which help to the control the mechanism of growth in the plant.

Plant growth regulators are variously described as plant growth substances, plant hormones or phytohormones. These are the small, simple organic molecules of diverse chemical composition produced naturally in higher plants that controls the growth and other physiological functions. These are required in a very small amount by the plant.

Classification of Plant Growth Regulators
The plant growth regulators falls under the following categories
(i) Indole compounds, e.g., Indole Acetic Acid (IAA)
(ii) Adenine derivatives, e.g., forfuryl amino purine, kinetin
(iii) Carotenoid derivatives, e.g., Abscisic acid (ABA)
(iv) Terpenes, e.g., Gibberellic acid (mainly)
(v) Gases, e.g., Ethylene .

On the basis of junctions they perform in a living plant body in broad terms, PGRs are divided into two groups
1. Plant Growth Promoters
PGRs that shows growth promoting activities such as cell division, cell enlargement, tropic growth, pattern formation, flowering, fruiting, seed formation, etc., are called plant growth promoters, e.g., auxins, gibberellins and cytokinins.

2. Plant Growth Inhibitors
These perform function in response to wounds and stresses i.e., of biotic and abiotic origin. These are also involved in various growth inhibiting activities like dormancy and abscission, e.g., Abscisic acid.

The gaseous form of PGR, i.e., ethylene, can fit in either category and may function both as promoter and inhibitor. But largely it functions as an inhibitor of growth activities.

Discovery of Plant Growth Regulators
It is interesting to know that the discovery of all five major groups of plant growth regulators have been done accidentally. All these help in understanding the phenomenon of development and abnormalbehaviour in plants.

1. Discovery of Auxin
This was the first growth hormone to be discovered. It come into existence through the observation of Charles Darwin and his son Francis Darwin.

They observed the coleoptiles of canary grass that responded to unilateral illumination by growing towards the source of light (phenomenon known as photo-periodism).

After performing series of experiments they came to the conclusion that coleoptile tip was the site that has the property of transmittable influence due to which bending of complete coleoptile was caused. The first PGR i.e., auxin was isolated by FW Went in 1928, from coleoptile tip of oat seedlings.

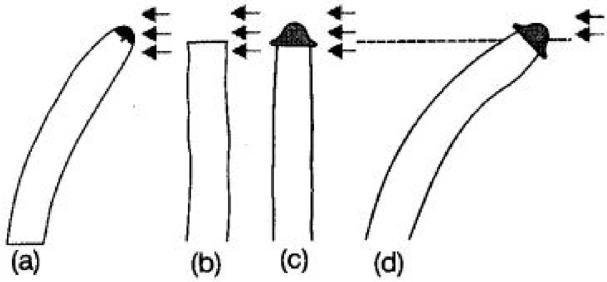


Fig. 15.10 Experiment used to demonstrate that tip of the coleoptile is the source of auxin. Arrows indicate direction of light

2. Discovery of Gibberellins
In early part of 20 century. The bakane (foolish seedlings), was reported to be caused by a fungal pathogen Gibberella fujikuroi, symptoms shown by the plant

were elongated stems, little or no production of grains and plant became weak thus, it was later identified that the active substances was gibberellic acid.

The Japanist plant pathologist E Kurosawa, reported the appearance of symptoms of the disease in uninfected rice seedlings when they were treated with sterile filtrate of fungus.

3. Discovery of Cytokinins

F Skoog and his coworkers, while studying the nutritional requirements of tissue culture derived from the internodal segments of tobacco stems, observed that from that internodal segments, a callus (i.e., a mass of undifferentiated cells) proliferated, only when the nutrient medium containing auxin was supplemented with the extract of vascular tissues or yeast or coconut milk (water of endosperm of coconut) or DNA.

It was later found that the active substances were a modified form of adenine which was crystallised and identified as Kinetin. Further the compounds that exhibited kinetin like properties were termed as cytokinins.

4. Discovery of Abscisic Acid
With the progression in the research on plant growth regulators three independent researchers reported the purification and chemical characterisation of three different kinds of inhibitors (during mid I960), i.e., inhibitor B, abscission II and dormin. Later, three were proved to be chemically identical in nature and were named Abscisic Acid (ABA).

5. Discovery of Ethylene
Cousins (1910), confirmed the release of a volatile substance from ripened oranges that enhance the ripening of stored unripened bananas. This volatile substance was later identified to be a gaseous plant growth regulators, i.e., ethylene.

Physiological Effects of Plant Growth Regulators

All five categories of plant growtbregulators discussed above are described have under with their physiological effects on the growth of the plant
1. Auxins
Auxin (Gk. auxein to grow) was initially isolated from the urine of human, but later

on, their presence was also found in plants and was proved to be the first PGR ever known. The real plant auxin is chemically known as Indole -3-Acetic Acid (IAA).

The term is also applied to other natural and synthetic compounds having various growth regulating properties. Production of auxin generally takes place in the region of growing apices of the stems and roots from where they migrates to the site of their action.
Auxins can move only through cell to cell by diffusion, i.e., they cannot move through vascular tissues.

Types of Auxins
There are generally two basic categories in which auxins are divided
a. Natural Auxins
It occur naturally in plants and fungi e.g., Indole Actic Acid (IAA) and Indole Butyric Acid (IBA).

b. Synthetic Auxins
These are prepared from synthetic compounds that causes several responses to IAA. They can easily move in all directions inside the plants, e.g., Naphthalene Acetic Acid (NAA), 2-4- dichlorophenoxyacetic acid (2, 4-D).
All these types of auxins are extensively been used in agricultural and horticultural practices.

Note:

- The compounds, which can be converted into auxins, are called auxin precursors, e.g., IAA is synthesised from tryptophan hormone.
- The compounds, which inhibit the actions of auxins, are termed anti- auxins.
- lndole-3 acetic acid is a derivative of an amino acid tryptophan.

Functions of Auxins
Auxins performs several junctions, these are as follows
(a) Cell Elongation . Auxin stimulate the elongation of cells of shoots.

(b) Initiation of Roots In contrast to stem, higher concentration of auxin inhibits the elongation of shoots, but it initiates more lateral branches of roots.

(c) Inhibition of Abscission Natural auxins delay abscission of young fruits and leaves and also used to control pre-harvest fruit drop.

(d) Apical Dominance Presence of auxin in higher concentration (in higher plants) in shoot apex, promotes apical dominance. It is been seen commonly in many vascular plants, that presence of apical buds does not allow the lateral buds to grow. They only start developing into branches when the apical bud is removed.

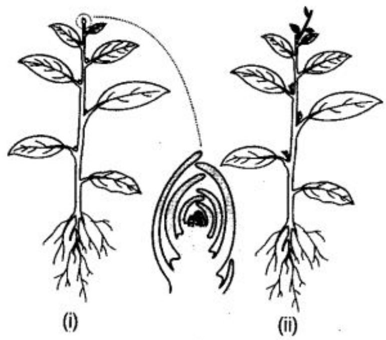


Fig. 15.11 Apical dominance in plants (i) A plant with apical bud intact (ii) A plant with apical bud removed

(e) Promotes Flowering Presence of auxin helps in promoting flowering in pineapple litchi, etc.

(f) Parthenocarpy Auxins are used to unpollinated pistil and make them develop into parthenocarps, which carry a better market value.

(g) Metabolism Application of auxin can enhance metabolism due to mobilisation of plant resources.

Applications of Auxins
As stated, use of synthetic auxins is widely accepted now-a-days in various agricultural and horticultural practices.

Following are the applications of auxins
(a) Eradication of Weeds Auxins are used as weedicides and herbicides. Application of 2, 4-dichlorophenoxyacetic acid (2, 4-D) is widely done in order to kill dicotyledonous weeds. It inflict does not affect mature, monocotyledonous plants.
The growth of lateral buds into branches after decapitation.
(b) Helps in Cell Division Besides cell elongation auxin may also be active in cell division.
(c) Controls Xylem and Phloem Differentiation Auxin controls differentiation of xylem and phloem is stems and roots. There are evidences that low concentration of auxin induces phloem differentiation while higher concentration of auxin is responsible for differentiation of both xylem and phloem tissues.

2. Gibberellins

These are another kind of plant growth regulators, which are known to be weakly acidic growth hormones. There are more than 100 different gibberellins reported from widely different organisms like fungi and higher plants. All of them are known to be acidic in nature, . thus, they are termed as Gibberellic Adds (i.e„ GA , GA_1 , GA_2 and so on). However, GA_3 is the most important gibberellic acid which was first to be discovered. It was most extensively studied.

Functions of Gibberellins

Gibberellins show various important physiological effects
(a) Elongation of Internodes It elongate the internodes so, as to increase the height of the plant. They cause an increase in length of axis and is also used in increasing length of grapes stalks.

(b) Elongation of Genetically Dwarf Plants It has been seen that if gibberellins are administered to a dwarf plant (pea, maize, etc), it may help in overcoming dwarfism. It also causes fruits to elongate and improve their shape, e.g., in apples etc.

(c) Bolting and Flowering The gibberellins also helps in promoting bolting (internode elongation) just prior to their reproductive phase or flowering. This is seen in rosette plants like beet, cabbage as these plants shows retarded internodal growth and profuse leaf development. Rosette plants require either long days or cold night for bolting process and for the initiation of flowering.

(d) Breaking Dormancy It also helps in overcoming natural dormancy of buds, tubers, seeds, etc, and allows them to grow.

Seed Dormancy

The state of the seed is said to be the dormant state when it remains dry and non-germinating. Thus, by 'breaking seed dormancy', we simply mean, to make the seed to germinate.
(e) Flowering This can also be induced in long day plants by the action of gibberellins.

Applications of Gibberellins

Gibberellins, apart from showing varied .physiological effects, also have numerous application.
These are as follows

(a) Delays Senescence Gibberellins can delay the ripening of fruits such as Citrus fruits, apples, etc. This can be also used for safe and prolonged storage of the fruits.

(b) Malting Process The process of malting in brewing industry can be speedup by the use of GA_3 .

(c) Sugar Yield As carbohydrate is stored in the form of sugar in the stems of sugarcane. Thus, if crop of sugarcane is sprayed with gibberellins. It results in increased length of the stem. This, enhance, increases the yield of sugarcane as much as 20 tonnes per acre.

(d) Early Seed Production like and when sprayed on juvenille conifers, hastens the maturity period of them leading to early seed production.

Cytokinins
These are growth promoters that are basic in nature. They have specific effects on cytokinesis (division of cytoplasm) and were discovered as kinetin (a modified form of adenine, a purine).
Lethometal (1964) while searching for a substance with cytokinin like activity isolated Zeatin from corn kernels and coconut milk. Now presendy, several naturally occurring cytokinins and some synthetic compounds having cell division promoting activities have been identified after the discovery of Zeatin.

Region of Synthesis of Cytokinins
Natural cytokinins are known to be synthesised in the regions where rapid cell division takes place, e.g., root apex, developing shoot buds, young fruits, etc., out of these roots are the major source of synthesis of cytokinins, from where, they move upwards through xylem.

Naturally Occurring Cytokinins
Coconut milk factor The liquid endosperm of coconut is known as coconut milk. This contains some factors, that shows kinetin like activity and enhance, stimulate the growth in many plant tissues (in vitro). All these factors are collectively called as 'coconut milk factor'. These represents an example of naturally occurring cytokinins?
Zeatin It is also a naturally occurring cytokinin, isolated from maize grains. It is remarkably known to be more active than any other cytokinin.

Functions of Cytokinins

Cytokinins have following remarkable physiological effects

(a) Promotes cell division This is one of the most common and important biological effect of kinetin on plants, i.e., to induce cell division in the presence of sufficient amount of auxin (IAA).

(b) Reduces apical dominance They promote the growth of lateral buds by breaking apical dominance.

(c) Morphogenesis Differentiation or morphogenesis of plants tissues/organs is seen to be in control, if ratio of cytokinins and auxins is proportionate.

(d) Resistance They also increase resistance of plants to high or low temperature and diseases.

(e) Delays senescence These also helps in delaying senescence (ageing) of leaves and other organs by controlling synthesis of protein and mobilisation of resources or nutrients.

Applications of Cytokinins

(a) Tissue culture Cytokinins are essential for tissue culture; apart from cell division they are also involved in morphogenesis.

(b) Shelf life Administration of cytokinins to harvest fruits and vegetables keeps them fresh for several days and increase their shelf life.

Shelf life of flowers and cut shoots can also be increased by using cytokines.

4. Ethylene

It is a simple gaseous plant growth regulator, which is synthesized from the amino acid methionine. In plants synthesis of ethylene takes place in almost every part of the plant, i.e., roots, leaves, flowers, seeds, fruits, etc. Most important effect of ethylene is promotion of senescent changes in the plant. Thus, it is synthesized by tissue in large amounts that undergo senescence and also by ripening fruits due to this property it is also known as fruit ripening hormone.

As ethylene is a volatile substance, its production in one plant may influence the growth of other plants near to it.

Functions of Ethylene

Ethylene shows various important physiological effects

(a) In dicot seedlings, ethylene influences the horizontal growth of seedling, swelling of the axis and formation of apical hook.

(b) It is highly effective in fruit ripening. It also increases the rate of respiration. This rise in the respiration rate is called respiratory climacteric.

(c) Helps in breaking seed and bud dormancy.
(d) Initiation of germination in peanut seeds and sprouting of potato tubers is also due to the production of ethylene in plants.
(e) In deep water rice plants, ethylene promotes rapid internode petiole elongation.
(f) It proves to be helpful in increasing absorption surface of plants by promoting growth of root and formation of root hairs.
(g) It also stimulates flowering in fruits like pineapple, mango and other related plants.
Ethylene apart from so many positive responses also has negative feedback.
Release of ethylene commonly inhibits the synthesis of auxins.

Applications of Ethylene
As ethylene helps in regulating these many physiological process in plants. It is known to be the most widely used PGR in agricultural field.

Ethephon. It is the most widely used compound as a source of ethylene. This tends to absorbs readily in an aqueous solution and transported within the plant. This slowly releases ethylene.

(a) Ethephon is known to control fruit ripening (in tomatoes and apples).
(b) It also helps in accelerating abscission in flowers and fruits (causes thining of fruits like cotton, cherry, walnut, etc).
(c) Helps in promoting female flowers inhance, the yield of the fruits, e.g., Cucumber.

5. Abscisic Acid
It is slightly acidic growth hormone that functions as a growth inhibitor by interacting with other mentioned growth hormones, i.e., auxins, gibberellins and cytokinins.
Thus, like other PGR, abscisic acid also has a wide range of effects on growth and development of plants.
As its production is stimulated under stress (unfavourable conditions such as drought, water lodging, excessive temperature, etc). Thus, it is known as stress hormone. It acts antagonistically to gibberellic acid.
This hormone is transported to all parts of the plants through the process of diffusion by conductive channels.

Functions of Abscisic Acid
Abscisic acid shows various important physiological effects

(i) It has a primary role in regulating abscission and dormancy of buds and seeds. By inducing dormancy it helps the seeds to withstand the desiccation and other factors related to unfavorable growth.
(ii) It acts as a general plant growth inhibitor and also inhibits metabolism of plants.
(iii) It has its role in inhibition of seed germination.
(iv) Also plays an important role in seed development and maturation.
(v) Abscisic acid stimulates the closure of stomata.
Abscisic acid is also known as dormin as promotes several kinds of dormancy in plants.

The Mechanism of Stomatai Ciosmg by ABA
ABA binds to receptors of the plasma membrane at the surface of the guard cells.

The receptors in turn activate several interconnecting pathways, which causes a rise in pH in the cytosol promoting the transfer of Ca^{+2} from the vacuole to the cytosol.

All this causes stomata to close, and opening of stomata occurs when conditions are just reverse to it.
Interaction between Growth Regulators

For the regulation of every phase of growth, i.e., for differentiation and developmental processes in plants two or more phytohormones are intimately related to each other. These can either act synergistically or antagonistically. Thus, every PGR has one or the other role to play. Likewise, there are also number of events in the life of a plant where more than one PGR is also involved to affect that particular event to takes place, e.g.,

(i) Dormancy of seeds and buds is mostly due to abscisic acid, while it is broken down by gibberellins.
(ii) Auxins and cytokinins acts antagonistically in controlling apical dominance, i.e., auxins causes apical dominance, while cytokinins helps to overcome them.
(iii) Senescence is prevented by both auxins and cytokinins, while its stimulation is done by abscisic acid.
(iv) Auxins and cytokinins acts synergistically in promoting cell division.

Plant Growth and Development Class 11 MCQs Questions with Answers

Question 1.
Mechanism of development was explained by
(a) Hans Dietrisch
(b) Spemann
(c) Both a and b
(d) Haemmerling

Answer
Answer: (c) Both a and b

Question 2.
Intercalary meristems are of
(a) Permanent nature
(b) Temporary nature
(c) Some are permanent some temporary
(d) None of these

Answer
Answer: (b) Temporary nature

Question 3.
Cells of fibers and tracheids elongate during
(a) Phase of cell division
(b) Phase of cell elongation
(c) Phase of cell maturation
(d) Phase of cell differentiation

Answer
Answer: (a) Phase of cell division

Question 4.
Typical plant growth shows __________ curve.
(a) J-shaped
(b) S-shaped
(c) I-shaped
(d) Parabolic

Answer

Answer: (b) S-shaped
Explanation:
Typical plant growth represents sigmoid curve.

Question 5.
Exponential growth of the plants is express as $W_1 = W_0 e^{rt}$ r represents
(a) ability of the plant to produce new cells
(b) efficiency index
(c) relative growth rate
(d) all of the above

Answer
Answer: (d) all of the above
Explanation:
r is the relative growth rate and also measures the ability of the plant to produce new plant material (efficiency index).

Question 6.
Opening of floral buds into flowers, is a type of:
(a) Autonomic movement of variation
(b) Autonomic movement of locomotion
(c) Autonomic movement of growth
(d) Paratonic movement of growth

Answer
Answer: (c) Autonomic movement of growth

Question 7.
Which one is incorrect?
(a) Epiblast is presumptive ectoderm and mesoderm
(b) Hypoblast is presumptive endoderm
(c) Hypoblast is presumptive mesoderm
(d) Upper layer of cells in blastoderm is epiblast

Answer
Answer: (c) Hypoblast is presumptive mesoderm

Question 8.
The stage of rapid cell division just after fertilization is
(a) Organogenesis
(b) Cleavage
(c) Gastrulation
(d) Growth

Answer
Answer: (b) Cleavage

Question 9.
Plants grow throughout their life due to
(a) presence of meristems
(b) presence of vascular cambium
(c) presence of xylem and phloem
(d) presence of tracheids

Answer
Answer: (a) presence of meristems
Explanation:
Plants growth throughout their life due to the presence of meristems at certain locations in their body.

Question 10.
Liver and pancreas arise from
(a) Foregut
(b) Midgut
(c) Hindgut
(d) None of these
Answer
Answer: (a) Foregut

Question 11.
Which one of the followings is a gaseous plant hormone?
(a) Ethylene
(b) Gibberellin
(c) IAA
(d) Abscisic acid

Answer
Answer: (a) Ethylene

Question 12.
To prevent over – ripening, bananas should be
(a) given a dip in ascorbic acid
(b) maintained at room temperature
(c) refrigerated
(d) stored at the top of refrigerator
Answer
Answer: (c) refrigerated

Question 13.
Growth in dorsiventral leaf is measured in terms of
(a) length of leaf
(b) increase in cell number
(c) surface area increase
(d) none of these
Answer
Answer: (c) surface area increase
Explanation:
Increase in surface area denotes the growth in a dorsiventral leaf.

Question 14.
Mechanism of development was explained by
(a) Hans Dietrisch
(b) Spemann
(c) Both a and b
(d) Haemmerling
Answer
Answer: (c) Both a and b

Question 15.
The ability to regain or recover the lost or injured part of body is
(a) Aging
(b) Regeneration
(c) Abnormal development
(d) Primary inductio

Answer
Answer: (b) Regeneration

Question 16.
Which growth hormone accerlates the malting process in brewing industry?
(a) Auxins
(b) Gibberellins
(c) Ethylene
(d) Cytokinins
Answer
Answer: (b) Gibberellins
Explanation:
Gibberellins especially GA3 is used to speed up the malting process in brewing industry.

Question 17.
Which plant growth regulator is the derivative of carotenoids?
(a) Auxin
(b) Gibberelic acid
(c) Cytokinin
(d) Abscisic acid
Answer
Answer: (d) Abscisic acid
Explanation:
Abscisic acid are the derivatives of carotenoids.

Question 18.
Typical plant growth shows __________ curve.
(a) J-shaped
(b) S-shaped
(c) I-shaped
(d) Parabolic

Answer
Answer: (b) S-shaped
Explanation:
Typical plant growth represents sigmoid curve.

Question 19.
Mobilisation of stored food in germinating seeds is triggered by
(a) auxins
(b) cytokinins
(c) gibberellins
(d) ethylene
Answer
Answer: (c) gibberellins

Question 20.
Cavity formed between somatic and splanchnic mesoderm is called
(a) Gastrocoele
(b) Blastocoele
(c) Coelom
(d) Neurocoele
Answer
Answer: (c) Coelom

Solutions for Class 11 Biology Chapter 15 Plant Growth and Development:

Section Name	Topic Name
15	Plant Growth and Development
15.1	Growth
15.2	Differentiation, Dedifferentiation and Redifferentiation
15.3	Development
15.4	Plant Growth Regulators
15.5	Photoperiodism
15.6	Vernalisation
15.7	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1. Define growth, differentiation, development, dedifferentiation, redifferentiation, determinate growth, meristem and growth rate.

Solution: Growth is defined as a vital process which brings about an irreversible and permanent change in the shape, size, form, weight and volume of a cell, organ or whole organism, accompanied with increase in dry matter.
Differentiation is a localised qualitative change in size, biochemistry, structure and

function of cells, tissues or organs, e.g., fibre, vessel, tracheid, sieve tube, mesophyll, leaf etc. Thus it is a change in form and physiological activity. It results in specialisation for particular functions.
Development may be defined as a process which includes growth, differentiation and maturation in a regular sequence in the life history of a cell, organ or organism viz., seed germination, growth, differentiation, flowering, seed formation and senescence. Dedifferentiation is the process by which the differentiated cells which have lost the ability to divide under certain circumstances, become meristematic and regain the divisibility. Redifferentiation is defined as maturation or differentiation of dedifferentiated cells to form cells which are unable to divide e.g., secondary xylem elements, cork cells etc., are formed by redifferentiation of secondary cambial cells.
Determinate growth is the ability of a cell, tissue or the organism to grow for a limited period of time. Meristem is a tissue consisting of unspecialised immature cells, possessing the power of continuous cell division and adding new cells to the body. Growth rate is defined as the increased growth per unit time.

2. Why is not any one parameter good enough to demonstrate growth throughout the life of a flowering plant?

Solution: A flowering plant consists of a number of organs viz., roots, stem, leaves, flowers, fruits etc. growing differently under different stages of life cycle. These plant organs require different parameters to demonstrate their growth. In plant organs like fruits, bulbs, corms etc. fresh weight is used for measuring their growth. In case of fruits, increase in volume, diameter etc., are also used as other parameters for the measurement of their growth. For flat organs like leaves, increase in surface area is used as the parameter. Stem and roots primarily grow in length and then in girth, thus increase in length and diameter are used for measuring their growth. Consequently, the flowering plants exhibit several parameters to demonstrate growth.

3. Describe briefly
(a) Arithmetic growth
(b) Geometric growth
(c) Sigmoid growth curve
(d) Absolute and relative growth rates

Solution: (a) Arithmetic growth: If the length of a plant organ is plotted against time it shows a linear curve, the growth is called arithmetic growth. In this growth, the rate of growth is constant and increase in growth occurs in arithmetic progression e.g., length of a plant is measured as 2,4, 6, 8,10,12 cms at a definite interval of 24 hrs. It is found in root or shoot elongating at constant rate. Arithmetic growth is expressed as $L_t = L_0 + r_t$ Here, L_t = length after time t. L_0 = length at the beginning, r = growth rate.

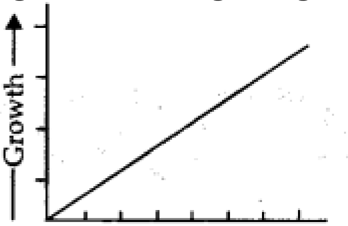


Fig.: Arithmetic growth curve

(b) Geometric growth: Geometric growth is the growth where both the progeny cells following mitosis retain the ability to divide and continue to do so. It occurs in many higher plants and in unicellular organisms when grown in nutrient rich medium. Number of cells is initially small so that initial growth is slow which is called lag phase. Later on, there is rapid growth at exponential rate. It is called log or exponential phase.

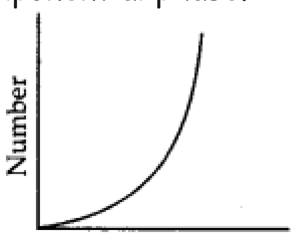


Fig.: Geometric growth curve

(c) Sigmoid growth curve: Geometric growth cannot be sustained for long. Some cells die. Limited nutrient availability causes slowing down of growth. It leads to stationary phase. There may be actually a decline. Plotting the growth against time will give a typical sigmoid or S-curve.

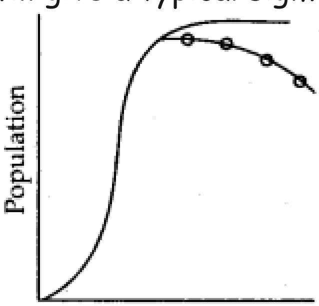


Fig.: Sigmoid growth curve

S-curve of growth is typical of most living organisms in their natural environment. It also occurs in cells, tissues and organs of plants.

(d) Absolute growth rate is the measurement of total growth per unit time.
Relative growth rate is growth per unit time per unit initial growth.
Growth in given time period/ Measurement at start of time period
Suppose two leaves have grown by 5 cm^2 in one day. Initial size of leaf A was 5 cm^2 while that of leaf B was 50 cm^2. Though their absolute growth is the same (5 cm^2/day), relative rate of growth is faster in leaf A(5/5) because of initial small size than in leaf B(5/50).

4. List five main groups of natural plant growth regulators. Write a note on discovery, physiological functions and agricultural/ horticultural applications of any one of them.
Solution: There are five main groups of natural plant growth regulators which are very much recognised as natural hormones in plants. These are:

1. Auxins
2. Gibberellins
3. Cytokinins
4. Abscisic acid
5. Ethylene

Discovery of auxin: In 1880, Charles Darwin and Francis Darwin worked with the coleoptile of canary grass (Phalaris sp.) and found the existence of a substance in coleoptile tip, which was able to recognise the light stimulus and leads to the bending of tip towards light. Boysen and Jensen (1910-1913) worked on Avena seedling and explained that the substances secreted in the tip are soluble in water (gelatin).
Paal (1919) reported that the substances secreted in the tip are translocated downwards and caused cell elongation in half portion which was on the dark side and hence bending was observed in opposite direction.
F.W. Went (1928) further refined this experiment and supported the observations of Paal. He was the first person to isolate and name these substances of tip as auxins (Greek Auxein – means 'to grow').
In 1931, Kogl and Haagen-Smith isolated crystalline compounds from human urine. These were named as auxin-a, auxin-b and heteroauxin.

Physiological functions of auxins:

1. Auxins induce cambial cell divisions, shoot cell elongation and early differentiation of xylem and phloem in tissue culture experiments.
2. In general, auxins initiate rooting but inhibit the growth of roots. IBA is the most potent root initiator.
3. Auxins inhibit the growth of axillary buds (apical dominance) but enhance the size of carpel and hence earlier fruit formation.
4. Application of auxins retards the process of senescence (last degradative phase), the abscission of leaves, fruits, branches, etc.
5. Auxins induce feminisation, i.e., on male plant, female flowers are produced.

Agricultural/horticultural application of auxins:

1. Application of auxins like IAA, IBA, NAA induce rooting in stem cuttings of many plants. This method is widely used to multiply several economically useful plants.
2. Normally, auxins inhibit flowering however in litchi and pineapple, application of auxin promotes flowering thus used in orchards.
3. Auxin induces parthenocarpy in some plants including tomato, pepper, cucumber and Citrus, thus, produces seedless fruits of more economic value.
4. Auxins like 2, 4-D and 2, 4, 5-T are commercially used as weedicides, due to their low cost and greater chemical stability. They are selective herbicides (killing broad-leaved plants, but not grasses).
5. For checking premature fruit drop, auxins are applied which prevent the formation of abscission zone in the petiole or just below the fruit. Auxin regulates maturing fruit on the trees of apples, oranges and grape fruit. High doses of auxins can
   cause fruit drop. Thus, heavy applications of synthetic auxins are used commercially to promote a coordinated abscission of various fruits to facilitate harvesting.
6. Auxin, produced in the apical bud, suppresses the development of lateral buds, i.e., apical dominance. Thus practically used in prolonging the dormancy period of potato tubers.
7. Naphthalene acetamide is used to prevent the lodging (excessive elongation and development of weak plants, specially in gramineae) or falling of crops.
8. Auxin (2,4-D) promotes callus formation in tissue culture. Complete plantlets are regenerated from callus tissue, using auxins and cytokinin which are then transplanted into the soil. Now-a-days, this is a widely practised method of propagation in the field of agriculture and horticulture.

5. What do you understand by photoperiodism and vernalisation? Describe their significance.

Solution: The physiological mechanism for flower-ing is controlled by two factors: photoperiod or light period, i.e., photoperiodism and low temperature, i.e., vernalisation. Photoperiodism is defined as the flowering response of a plant to relative lengths of light/ dark period. Significance of photoperiodism is as follows:

1. Photoperiodism determines the season in which a particular plant shall flower. For example, short day plants develop flowers in autumn-spring period (e.g., Dahlia, Xanthium) while long day plants produce flowers in summer (e.g., Amaranthus).
2. Knowledge of photoperiodic effect is useful in keeping some plants in vegetative growth (many vegetables) to obtain higher yield of tubers, rhizomes etc. or keep the plant in reproductive stage to yield more flowers and fruits.
3. A plant can be made to flower throughout the year by providing favourable photoperiod.
4. Helps the plant breeders in effective cross-breeding in plants.
5. Enable a plant to flower in different seasons.

   Vernalisation is promotion or induction of flowering by exposing a plant to low temperature for some time. Significance of vernalisation is as follows :

   (i) Crops can be grown earlier.

   (ii)Plants can be grown in such regions where normally they do not grow.

   (iii)Yield of the plant is increased.

   (iv)Resistance to cold and frost is increased.

   (v) Resistance to fungal diseases is increased.

6. Why is abscisic acid also known as stress hormone?

Solution: A fairly high concentration of abscisic acid (ABA) is found in leaves of plants growing under stress conditions, such as drought, flooding, injury, mineral deficiency etc. It is accompanied by loss of turgor and closure of stomata. When such plants are transferred to normal conditions, they regain normal turgor and ABA concentration decreases. Since the synthesis of ABA is accelerated under stress condition and the same is destroyed or inactivated when stress is relieved, it is also known as stress hormone.

7. 'Both growth and differentiation in higher plants are open'. Comment.

Solution: Plant growth is generally indeterminate. Higher plants possess specific areas called meristems which take part in the formation of new cells. The body of plants is built on a modular fashion where structure is never complete because the tips (with apical meristem) “are open ended – always growing and forming new organs to replace the older or senescent ones. Growth is invariably associated with differentiation. The exact trigger for differentiation is also not known. Not only the growth of plants are open- ended, their differentiation is also open. The same apical meristem cells give rise to different types of cells at maturity, e.g., xylem, phloem, parenchyma, sclerenchyma fibres, collenchyma, etc. Thus, both the processes are indeterminate, unlimited and develop into different structures at maturity i.e., both are open.

8. ‘Both a short day plant and a long day plant can produce flower simultaneously in a given place’. Explain.

Solution: A short day plant (SDP) flowers only when it receives a long dark period and short photoperiod, e.g., Xanthium, Dahlia etc. On the other hand, a long day plant (LDP) will flower only when it receives a long photoperiod and short dark period, e.g., wheat, oat etc. Thus critical photoperiod is that continuous duration of light which must not be exceeded in SDP and should always be exceeded in LDP in order to bring them to flower. Xanthium requires light for less than 15.6 hrs and Henbane requires light for more than 11 hrs. Xanthium (a SDP) and Henbane (DP) will flower simultaneously in light period between 11 to 15.6 hrs.

9. Which one of the plant growth regulators would you use if you are asked to
(a) induce rooting in a twig
(b) quickly ripen a fruit
(c) delay leaf senescence
(d) induce growth in axillary buds
(e) ‘bolt’ a rosette plant
(f) induce immediate stomatal closure in leaves.

Solution: (a) Auxins like IBA, NAA.
(b) Ethylene
(c) Cytokinins
(d) Cytokinins
(e) Gibberellins
(f) Abscisic acid (ABA)

10. Would a defoliated plant respond to photo- periodic cycle? Why?

Solution: No, a defoliated plant would not respond to photoperiodic cycle because photoperiodic stimulus is picked up by the leaves only. Even one leaf or a part of it is sufficient for this purpose. For perception of photoperiodic cycle, there must be the presence of leaves under inductive photoperiod, so that, the hormone responsible for flowering can be produced.

11. What would be expected to happen if:
(a) GA_3 is applied to rice seedlings
(b) dividing cells stop differentiating
(c) a rotten fruit gets mixed with unripe fruits
(d) you forget to add cytokinin to the culture medium.

Solution:

(a) The coleoptile will elongate rapidly, as GA_3 helps in cell growth.
(b) The development of callus (mass of undifferentiated cells) will take place.
(c) The unripe fruits will ripe quickly because of the increased rate of respiration due to emission of ethylene from rotten fruit.
(d) Cell division will retard and shoot will not initiate from the callus.

Digestion and Absorption Class 5 Notes Biology

- Topic 1 Digestion: The System and Associated Glands
- Digestive Glands
- Topic 2 Digestion : The Process and Control
- Enzymes from Pancreas

Topic 1 Digestion: The System and Associated Glands

Animals depend on ready-made food for their nutritional requirements. Nutrition is a process by which animal obtain essential and non-essential substances called nutrients.
The way by which organisms derive their nutrients is called mode of nutrition.

It is mainly of two types
(a) Autotrophic or Holophytic The organisms having the capability to form their own food with the help of solar energy, e.g., Plants, Euglena, etc. It is of further two types, i.e., photoautotropic and chemoautotrophic.
(b) Heterotrophic The organisms which cannot use free energy of our atmosphere to synthesise necessary organic compounds as food. These normally obtain the nourishment from the autotrophs.
Based upon the mode of feeding the heterotrophs can be
(i) Holozoic (ii) Saprozoic (iii) Saprophytic
(iv) Osmotrophic (v) Parasitic (vi) Predatorship

The myxotrophic nutrition is the case in which more than one type of . nutritional modes are found within the single animal. The animals like Euglena show this kind of nutrition.

A balanced diet has various components (carbohydrates, hits, proteins, vitamins, water, mineral and roughagfi) in optimum proportion and quantity.

Human Digestive System (Structure)
Biomacromolecules in food cannot be utilised by our body in original form. So, they are subject to a process called digestion (complex food substances are converted

to simple absorbable forms).
The system that helps in the complete process of digestion by mechanical and biochemical methods is called digestive system.

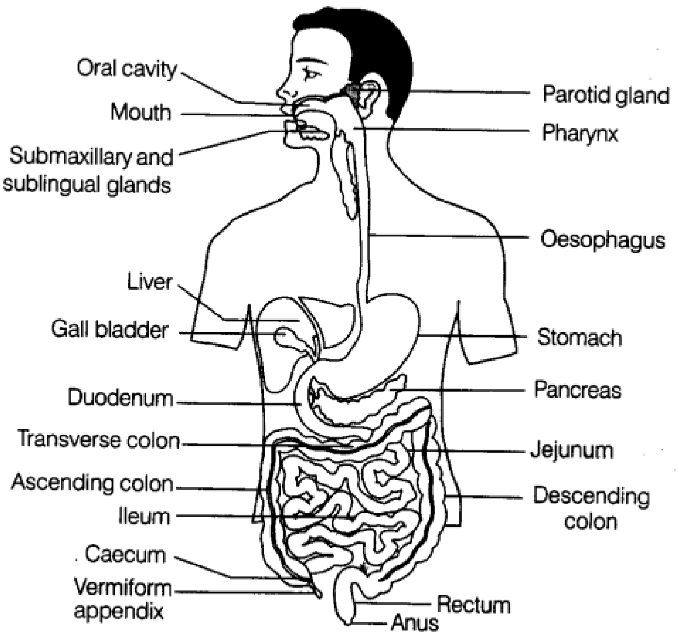


Fig. 16.1 The human digestive system

It is a long tube (about 8-10 m in length) with muscular walls and varying diameter. It begins with an anterior opening, i.e., mouth and opens out posteriorly through anus.
It is called canal (not tube), because it opens at both ends [i.e., mouth and anus).

Structure Wall of Alimentary Canal
If a transverse section of an alimentary canal is viewed, the wall of alimentary canal from oesophagus to rectum (large intestine) in general shows following four concentric layers
(a) Serosa It is the outermost layer made up of a thin mesothelium (epithelium of visceral organs) with some connective tissues.

(b) Muscularis It is the second coat present just below the serosa. It is a very thick and contains muscle fibre. It is formed by smooth muscles. It consists of outer longitudinal and inner circular muscle fibres (both are unstriped, i.e., smooth).

In some regions like stomach an additional layer of oblique muscle is found inner to the circular muscle fibres.

(c) Submucosa It lies below the muscular coat. Consist of loose connective tissues richly supplied with nerves, blood and lymph vessels and also with glands in some areas like duodenum. id) Mucosa It is the innermost layer lining the human gut or alimentary canal. It is named so, because it has its major role in secreting mucus in order to lubricate inner lining of gut.

This layer forms irregular folds (rugae) in the stomach and small finger-like folding called villi in the small intestine. It also forms gastric glands in the stomach.
All the four layer shows modification in different parts of the alimentary canal.

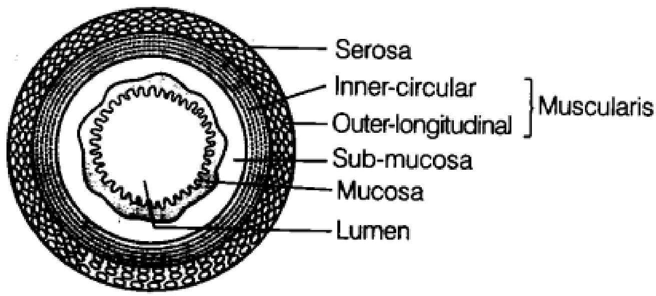


Fig. 16.2 Diagrammatic representation of TS of a gut

Various parts of alimentary canal are discussed below

i. Mouth and Buccal Cavity

Mouth is a slit like opening, bounded by two soft, movable lips. It opens into a small vestibule (space enclosed between lips and cheeks externally and gums and teeth internally), which inturn leads into the buccal or oral cavity.
Oral cavity further comprises of two main components a. Teeth
These are hard structures present in the mouth on both the jaws (i.e., upper and lower jaw). Each tooth is embedded in a socket of jaw bone.

Mammalian teeth are characterised by following three features

- Thecodont The teeth are fixed in sockets. They have very well-developed roots, which are implanted deeply in the jaw bone socket.
- Diphyodont Like other mammals, human beings also has two sets of teeth formed during lifetime. The first set of teeth is temporary and is known as milk or deciduous teeth.
  Milk teeth are 20 in number.
- The milk set is replaced by the second set known as permanent teeth or adult teeth. Permanent teeth last for whole life, if lost, cannot be replaced.

- Heterodont An adult human has 32 permanent teeth, but they are of different size, shape and type.
- They are of following four types
  - Incisors (I) for cutting of food
  - Canine (C) for tearing the food
  - Premolars (Pm)
  - Molars (M) for crushing, grinding and chewing the food.

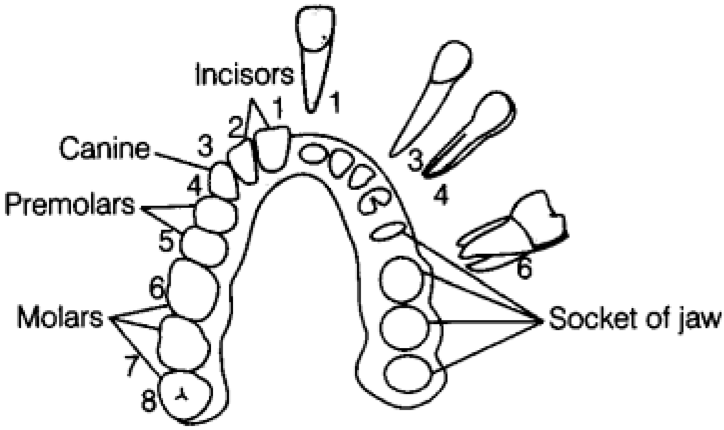


Fig. 16.3 Arrangement of different types of teeth in the jaws on one side and the sockets on the other side

i. Dental Formula

The number of each type of teeth can be expressed by a dental formula, which is the arrangement of teeth in each half of the upper and the lower jaw in the order I, C, Pm, M.

$$\text{Dental formula of humans} = \frac{2, 1, 2, 3}{2, 1, 2, 3} \times 2 = 32$$

$$\text{or} \qquad \frac{I, C, Pm, M}{I, C, Pm, M} \times 2 = 32$$

b. Tongue

It is a muscular organ, which is freely movable in the oral cavity. A fold called frenulum attaches the tongue to the floor of oral cavity. The upper surface of the tongue bears small projections (elevations) known as papillae. Some of the papillae bear taste buds.

Note:

- Papillae provides a characteristic roughness to the tongue.
- The hard visible chewing surface of tooth helps in the mastication of food and is covered by a thick, shiny and translucent substance called enamel (the hardest substance in the body).
- Taste buds present at the surface of the tongue contain chemosensory cells. Human taste buds are sensitive to four basic tastes, i.e., sweet, bitter, salty and sour. These four taste buds are present at different locations of the tongue.

ii. Pharynx

It is a small funnel-shaped chamber located behind the oral cavity. It serves as a common passage for both food and air, i.e., it communicates with both oesophagus (food pipe) and trachea (wind pipe).

The opening of trachea or wind pipe is called glottis, which is guarded by a cartilaginous flap or lid called epiglottis. The glottis normally remain open, but during swallowing of food it gets covered by epiglottis to prevent the entry of food in trachea.

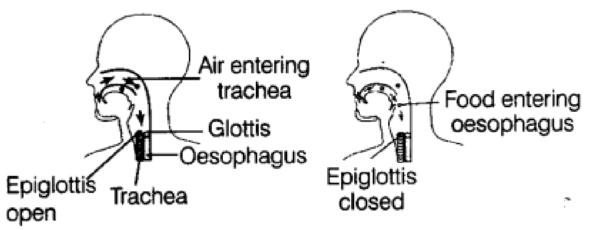


Fig. 16.4 Pharynx under normal condition and during swallowing

iii. Oesophagus

It is the thin, long muscular tube that extend posteriorly passing through the neck, thorax and diaphragm and finally leads into a J-shaped bag- like structure called stomach. A muscular gastro-oesophageal sphincter regulates the opening of oesophagus into the stomach.

iv. Stomach

It is the most dilated- structure of alimentary canal situated between the oesophagus and small intestine. It lies below the diaphragm in the abdominal cavity towards the upper left side.

Pails of Stomach

Stomach has three major parts as given below

(a) Cardiac stomach, the upper portion into which the oesophagus opens.
(b) Fundic stomach, the middle portion.
(c) Pyrolic stomach, the lower portion, which opens into the first part of small intestine, i.e., duodenum.
The terminal pyrolus part of stomach (i.e., opening of stomach into duodenum) is guarded by a pyrolic sphincter.

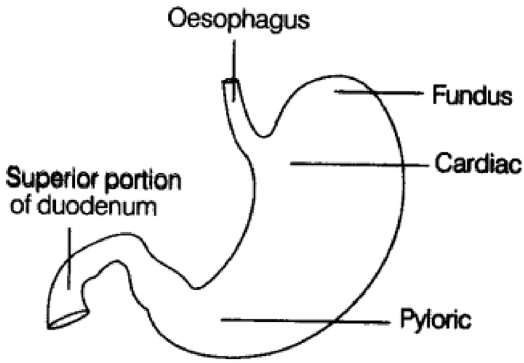


Fig. 16.5 Anatomical regions of human stomach

Functions of Stomach
Stomach serves the following Junctions
(a) Acts as a short term storage reservoir.
(h) The substantial chemical and enzymatic digestion is initiated here (especially of proteins).
(c) Gastric smooth muscles mix and grind the foodstuff by vigorous contractions with gastric secretions.
(d) Food become liquefied in the stomach and is released slowly in the small intestine.

Note:
The lymphatic tissues of the pharynx and oral cavity are arranged in a ring like manner, that are collectively called Waldeyer's ring. This ring consists of lingual tonsils and palatine tonsils.
The lower – part of oesophagus has only involuntary muscles.

v. Small Intestine
It is the longest part of the alimentary canal, which is about 6 m long in human beings.
It is divisible into three main reports
(a) Duodenum It is U-shaped, widest and shortest part of small intestine.
(b) Jejunum It is the middle part of small intestine, which is about 2.5 m long and

coiled.
(c) Ileum It is highly coiled and the longest portion of the small intestine, which and enormously increases the surface area of the intestine.

Absorptive Surface Area of Small Intestine
The structure of small intestine is similar to all other regions of the alimentary canal, but it incorporates three important features, which account for its huge absorptive surface area.

These are as follows
(a) Mucosal folds Inner surface of small intestine is thrown into circular folds, i.e., it is not flat.
(b) Villi The inner mucosa layer of small intestine has, villi (about 1 mm in height), covered with columnar epithelial cells.
(c) Microvilli Numerous microscopic projections of microvilli are produced by the cells lining the villi. These microvilli gives it a brush border appearance showing villi Functions of Small Intestine.

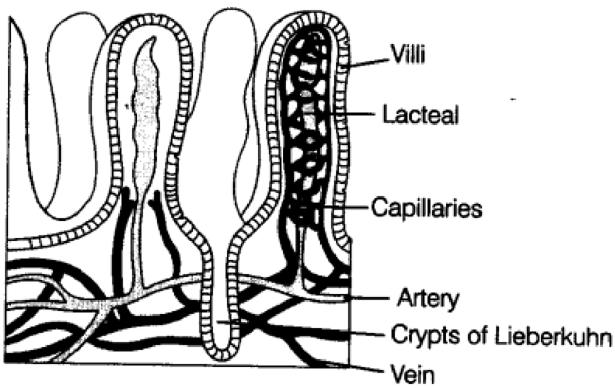


Fig. 16.6 A section of small intestinal mucosa showing villi

Following purposes are served by small intestine
(a) It acts as a major site for the digestion of food as it secretes most of the digestive enzymes and gastro-intestinal hormones.

(b) Maximum absorption of the end products of digestion takes place here, because it contains many villi that increases the surface area of absorption.

(c) It also helps in absorption of fats.
Although it is shorter but, is called large intestine, because it is wider in diameter than small intestine.

Large intestine lacks villi and microvilli
It is distinguishable into three main parts
(a) Caecum It is a small pouch-like structure connected to the terminal part of small intestine. It is a blind sac that functions as a host for various symbiotic microorganisms. Vermiform appendix, a narrow finger-like projection which is a vestigial organ arises from caecum.

Both the structures are not well-developed in human beings, but in herbivores it is developed very well in order to digest cellulose whose digestion is difficult.
finally opens into large intestine on the right side of the abdominal cavity.

(b) Colon It is the longest part of the large intestine. The caecum opens into colon, which is further divisible into three main parts, i.e., an ascending colon, transverse colon and descending colon.

(c) Rectum It is the last part of the large intestine. The descending colon finally opens into rectum, which serves to store the faecal matter temporarily. It further leads to a short anal canal, which opens to outside through anus.
The anal canal is guarded by another sphincter, i.e., internal and external sphincter,.
At the ileocaecal junction is an ileocaecal value is present, that regulates the passage of materials from small to the large intestines.

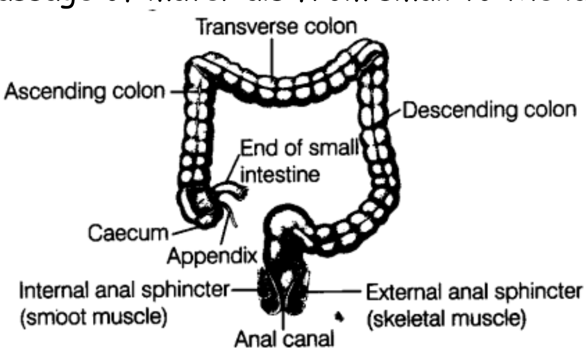


Fig. 16.7 Large intestine and its various parts

Digestive Glands

To bring about the chemical simplification of food, digestive juices are secreted by the different glands. The digestive glands associated with the alimentary canal include majorly salivary glands, the liver and pancreas.
i. Salivary Glands

These are exocrine glands that secretes saliva. There are three pairs of salivary glands in man. All three glands are situated just outside the buccal cavity and secrete salivary juice into the buccal cavity. These are as follows:
(a) Parotid Glands These are largest of the three glands present one on either side of the cheek on the upper palate.
(b) Sub-maxillary or Sub-mandibular Glands These are present at the angle of the lower jaw.
(c) Sub-lingual Gland These are situated beneath the tongue.
Each sublingual gland has about ten small duets called sub-lingual ducts or ducts of Rivinus, which open into the floor of mouth.

ii. Liver
It is the largest gland of the body, an exocrine gland. In adults, it weighs about 1.2-1.5 kg and lies in the abdominal cavity just below the diaphragm and has two lobes, i.e., left and right lobes.
It is a large organ and occupies most of the right side of abdominal cavity.

Liver is a double membrane structure. Interiorly, it is divided into many small units called hepatic or liver lobules (structural and functional units of liver) consisting of many hepatic cells (hepatocytes) that are arranged in the form of cords.

Each lobule is also covered by a thin connective tissue sheath called the Glisson's capsule. Hepatic cells secretes the bile juice, which passes through the hepatic duct into the gall bladder.

Functions of Liver
Liver serves the following functions
(a) It helps in producing RBCs in embryo.
(b) Bile secreted by the liver helps in emulsification of fats, i.e., breaking down of fats into very small micelles.
(c) Bile also activates lipases.
(d) It also produces heparin for preventing clotting of blood inside the blood vessels.

Gall Bladder
It is a small pear-shaped, thin muscular sac-like organ situated just below the liver. It is attached by connective tissues to liver. The duct of gall bladder, i.e.,

cystic'duct along with the hepatic duct form a common bile duct, which regulates the amount of bile to be discharged into the duodenum.

After certain distance, the bile duct and pancreatic duct (duct of pancreas) form common hepato-pancreatic duct, which open into duodenum. It is guarded by a sphincter called the sphincter of oddi.

The common hepato-pancreatic duct carries both the bile (from liver) as well as pancreatic juice (from pancreas) into the duodenum.

iii. Pancreas
It is a compound elongated organ situated partly behind the stomach between the limbs of the U-shaped duodenum. As it is a mixed gland, it has both exocrine as well as endocrine activity.
An alkaline pancreatic juice containing enzymes is secreted by its exocrine portion and the endocrine portion is responsible for the secretion of hormones, insulin and glucagon.

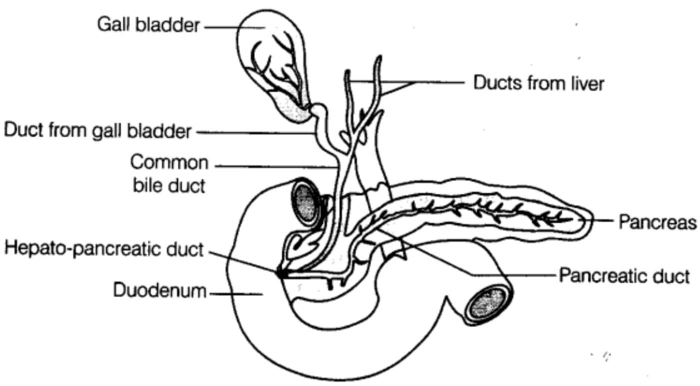


Fig. 16.8 Duct systems of liver, gall bladder and pancreas

Other Glands
Apart from the above mentioned major glands, other glands also plays an important role in completion of the process of digestion.

These are mentioned below as
Gastric Glands
The glands of stomach are called gastric glands. These are present in the mucosa of the stomach.
The gastric gland contains the following three types of secretory cells
(a) Mucus or goblet cells, secretes alkaline mucus.
(b) Peptic o(chief or zymogenic cells, secretes inactive precursors of gastric

enzymes.
(c) Parietal or oxyntic cells, secretes HCl and CIF (Castles Intrinsic Factor).

Intestinal Glands
The epithelium of intestine bears a large number of glands. Most of these glands are formed by the modification of the surface epithelial cells and are located on villi.
(a) Brunners glands are present only in the submiicosa of duodenum (not in ileum and jejunum).
(b) The lamina propria of small intestine contains large masses of lymphocyte cells called lymph nodules or Peyers patches. These help in destroying harmful bacteria of the region.
(c) The mucus portion contain simple, tubular intestinal glands or crypts of Leiberkuhn.

These are pit-like glands with three types of cell, i.e.,

- Undifferentiated epithelial cells
- Zymogenic cells or cells of Paneth
- Argentaffin or enterochromaffin cells.
- In general intestinal juice is called succus entericus (secretion of cells of crypts of Lieberkuhn mainly,
  i. e„ goblet cells and brush-bordered epithelial cells).

Note:

- The estimated number of gastric glands in humans is about 35 millions (3.5 crore).
- The unicellular goblet cells are also present in small intestine. Infact, these glands are present throughout the alimentary canal and secrete mucus.

Topic 2 Digestion : The Process and Control

The process of digestion involves the conversion of large, complex and non-diffusible substances into their respective simpler forms. The complete process of digestion is accomplished by mechanical and chemical processes.
Mobility of Gut
Alimentary canal being so long, does not allow the food to get jammed along its

length. This is due to the mobility of gut, which helps the food to move forward. The alimentary canal or gut shows following movements

i. In Buccal Cavity

The buccal cavity shows two major functions

(a) Mastication of Food It is the very first movement of the alimentary canal seen in buccal cavity. It involves the movement of teeth, which helps in chewing the food and the tongue, which help the food to mix thoroughly in the saliva, with the help of mucus.

The mucus lubricates and adhere the masticated particles of food into a bolus (mass of food that has been chewed before swallowing) and push it backward towards the pharynx for deglutition.

The mastication of food is a voluntary process (in human being).

(b) Swallowing (Deglutition) It is the process of passing bolus or mass of food in the oesophagus from the buccal cavity through pharynx.

The food is pushed back against the epiglottis, at the same time epiglottis covers the glottis (as already discussed in 1st topic). Due to this the oesophagus opening becomes wider and food enters it.

The bolus further passes down through the oesophagus by a successive wave (peristalsis) as a reflex along with the constriction of the oesophageal opening, which takes the food down towards the stomach.

ii. Peristalsis

It is the reflex wave that comprises of a series of muscle contraction that occurs in the complete digestive tract.

It pushes the food in the forward direction (away from the mouth).

Mechanism of Digestion

In human being, the digestion of food starts in the buccal cavity and continues till the anus of large intestine.

The mechanism of digestion continues in the following steps

i. Digestion in Buccal or Oral Cavity

Digestion starts in the oral cavity by the chemical hydrolytic action of the carbohydrate splitting enzyme, salivary amylase.

The saliva secreted into oral cavity contains electrolytes (Na^+, K^+, Cl^-, HCO_3, etc.) and enzymes, i.e., salivary
amylase and lysozyme (acts as an antibacterial agent that prevents infections). About 30% of the starch gets hydrolysed in the oral cavity by the action of salivary amylase (at optimum pH 6.8) into a disaccharide,
i. e., maltose.

$$\text{Starch} \xrightarrow[\text{pH 6.8}]{\text{Salivary amylase}} \text{Maltose}$$

ii. Digestion in Stomach

The stomach stores the food for around 4-5 hours. Internal mucosa of stomach contains gastric glands, which mainly comprises of three types ofcells

(a) Mucus or neck cells for secreting mucus.
(b) Peptic or chief or zymogenic cells for secreting proenzyme pepsinogen.
(c) Parietal or oxyntic cells for secreting HCl and intrinsic factor (essential for vitamin-B_{12} absorption).

The gastro-oesophageal sphincter controls the passage of food into the stomach. Food is slowly released from the stomach in small quantities into the small intestine, so that a slow process of digestion and absorption can occur.

The food mixes thoroughly with the acidic gastric juice secreted in the stomach by the churning movements of its muscles and becomes semi-digested, acidic, pulpy mass called chyme. The HCl and the enzymes of the gastric juice now helps in the chemical simplification of food.

The enzymes of stomach and their actions are given below

a. Pepsin

On exposure to HCl, the proenzyme pepsinogen gets converted into pepsin (proteolytic enzyme of the stomach) that further converts proteins into proteases and peptones (peptides).

$$\text{Pepsinogen} \xrightarrow{\text{HCl}} \text{Pepsin} \longrightarrow$$

$$\text{Proteins} \xrightarrow{\text{Pepsin (optimum pH 1-3)}} \text{Proteases} + \text{Peptones}$$

Pepsin usually attacks the peptide bonds between amino acids. It can attack all proteins except keratins, protamines, histones, etc.

b. Rennin
It is a proteolytic enzyme found in gastric juice of only infants, in its inactive form. Its secretion takes place in order to digest the milk proteins.

$$\text{Prorennin} \xrightarrow{HCl} \text{Rennin}$$

c. Gastric Lipases
Small amounts of lipases are also secreted by the gastric glands. Activity of this enzyme is inhibited in the stomach by the acidic condition.It act on emulsified fats and also help in digesting around 25% of milk fat (in infants).
It is mainly the digestion of proteins that occurs in the stomach.
Apart from all these enzymes, the amount of mucus and bicarbonates present in the gastric juice plays an important role in the lubrication and protection of mucosal epithelium from excoriation by the highly acidic pH.

iii. Digestion in Small Intestine
To further facilitiate the digestion of food, muscularis layer of small intestine shows various types of movements which allows a thorough mixing up of food with various secretions in the intestine.
These contractions of muscles in the small intestine allows the further churning and kneading of the chyme and finally pushing it into the large intestine.
The respective digestive juices from the liver (bile), pancreas (pancreatic juice) and srtiall intestine (intestinal juices) are released into the small intestine to bring out the further chemical simplification of food. The , pancreatic juice from the pancreas and the bile from the liver are released through the hepato-pancreatic duct.

Enzymes from Pancreas

The pancreatic juice secreted from the pancreas contains the various inactive enzymes.
These are as follows
(a) trypsinogen (b) chymotrypsinogen
(c) procarboxypeptidases (d) amylases (e) lipases (f) nucleases
Trypsinogen is activated by an enzyme enterokinase secreted by intestinal mucosa

into active trypsin which in turn activates the other enzymes of pancreatic juice.

$$\text{Trypsinogen} \xrightarrow[\text{pH (7-9)}]{\text{Enterokinase}} \text{Trypsin}$$

The proteins, proteases and peptones (partially hydrolysed form of proteins) present in the chyme (reaching the intestine) are acted upon by the proteolytic enzymes of pancreatic juice. These are given below as

$$\left.\begin{array}{l}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{array}\right\} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin / Chymotrypsin}} \text{Dipeptides}$$

Carbohydrates in the chyme are hydrolysed by pancreatic amylase into disaccharides.

$$\text{Polysaccharides (starch)} \xrightarrow{\text{Amylase}} \text{Disaccharides}$$

Nucleases in the pancreatic juice acts on nucleic acids to form nucleotides and nucleosides.

$$\text{Nucleic acids} \longrightarrow \text{Nucleotides} \longrightarrow \text{Nucleosides}$$

Enzymes from Liver

The bile secreted from the liver is released into duodenum of small intestine. Bile contains the bile pigments, i.e., bilurubin and biliverdin, bile salts, cholesterol and phospholipids.

Thus, fats are broken down into di and monoglycerides by the action of lipases.

$$\text{Fats} \xrightarrow{\text{Lipases}} \text{Diglycerides} \xrightarrow{\text{Lipases}} \text{Monoglycerides}$$

Note:

- Bile does not contain any enzymes as gastric juice. It helps in emulsifying fats, i.e., in breakdown of fats into very small micelles which are kept suspended in an aqueous medium.
- The process of emulsification is basically carried out by the salts of bile. This increases the surface area of fat available for digestion by the lipase (as bile also activates lipases).

Enzymes from Intestine

Intestinal mucosal epithelium has goblet cells (secretes mucus). Thus, the secretions of the brush border cells of mucosa together with the goblet cell secretions forms the intestinal juice (also known as succus entericus).

The succus entericus thus, contains various enzymes
(a) Disaccharidases, e.g., Maltase for digestion of maltose into glucose.
(b) Dipeptidases
(c) Lipases
(d) Nucleosidases

Pancreatic and intestinal lipases together helps in the emulsification of fats.
The mucus along with the bicarbonates from the pancreas helps in protecting the mucosal layer of intestine from the action of acid and also provides an alkaline medium (pH-7.8) for enzymatic activities.

Glands (Brunner's gland) from sub-mucosal layer of intestine also helps in this.
Hence, all the enzymes in the succus entericus acts on the end products of the above mentioned reactions in order to form their respective simpler forms.

$$\text{Dipeptides} \xrightarrow{\text{Dipeptidases}} \text{Amino Acids}$$

$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose + Glucose}$$

$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{Glucose + Galactose}$$

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose + Fructose}$$

$$\text{Nucleotides} \xrightarrow{\text{Nucleotidases}} \text{Nucleosides} \xrightarrow{\text{Nucleosidases}} \text{Sugars + Bases}$$

$$\text{Di and Monoglycerides} \xrightarrow[\text{Lipolytic enzyme}]{\text{Lipases}} \text{Fatty acids + Glycerol}$$

All these final steps takes place very close to mucosal epithelial cells of the intestine.
All the biomacromolecules mentioned above breakdown in the duodenum region of small intestine, while the simpler forms are absorbed in the other two regions of small intestine, i.e., jejunum and ileum.

Digestion in Large Intestine
The last stage of chemical simplification of food occurs in the last part of the alimentary canal, i.e., large intestine. This is carried out by bacterial action. Glands of this region tends to secrete mucus, i.e., enzymes are not secreted into this part of the digestive system.
The undigested and the unabsorbed substances are finally passed on to the large intestine.

Note:

- There are more than 500 species of bacteria found in the colon region of the large intestine which are not usually harmful as long as they remain in the large intestine.
- Infact, all these bacteria synthesise vitamin-K and B_{12} , also helps in absorption of calcium, magnesium and zinc (by increasing the acidity of colon region).

Following functions are performed by the large intestine
(i) Absorption of some water, minerals and certain drugs.
(ii) Secretion of mucus which helps in adhering the waste (undigested) particles together and lubricating it for an easy passage.

No significant digestive activity occurs in this region of digestive tract.

The undigested, unabsorbed substances called faeces, enters into the caecum region of the large intestine (through the ileo-caecal valve, which prevents the back flow of faecel matter). It is temporarily stored in the rectum till defecation (egestion) through the anus.

Apart from absorbing vitamins secreted by various types of bacteria, large intestine also helps in absorbing water and electrolytes such as Na^+, Cl^-.

Neural and Hormonal Control of Digestion
For proper coordination- and functioning of different parts of the gastrointestinal tract, it should be under a proper, neural and hormonal control.

Neural Control
Secretion of saliva is stimulated by the sight, smell and the presence of food in the oral cavity. Similarly, the gastric and intestinal secretions are also under the control of neural signals.
The muscular activities of different parts of the alimentary canal are also moderated by neural mechanisms (both local and through CNS).

Hormonal Control
The major hormones that control the functions of digestive system are produced and released by the cells in the mucosa of the stomach and the large intestine.

Digestion and Absorption Class 11 MCQs Questions with Answers

Question 1.
Function of HCl in stomach is to:
(a) Kill micro-organism of food
(b) Facilitate absorption of food
(c) Dissolve enzymes secreted by gastric glands
(d) Active trypsinogen to trypsin
Answer
Answer: (a) Kill micro-organism of food
Question 2.
Which of the following is different from others
(a) Gastrin
(b) Ptyalin
(c) Glucagon
(d) Secretin
Answer
Answer: (b) Ptyalin
Question 3.
Which one of the carbohydrate is monosaccharide:
(a) Glucose
(b) Sucrose
(c) Starch
(d) Cellulose
Answer
Answer: (a) Glucose
Question 4.
Protein are mainly required in the body for
(a) Growth
(b) Repair
(c) Both of the Above
(d) None of the Above
Answer

Answer: (c) Both of the Above
Question 5.
In frog, the surface of attachment of tongue is
(a) Hyoid apparatus
(b) Pterygoid
(c) Palatine
(d) Sphenoid
Answer
Answer: (a) Hyoid apparatus
Question 6.
Enterogastrone is:
(a) Hormone secreted by mucosa
(b) Enzyme secreted by mucosa
(c) Hormone secreted by duodenal mucosa
(d) Secreted by endocrine gland related to digestion
Answer
Answer: (c) Hormone secreted by duodenal mucosa
Question 7.
The cells in the wall of intestine are stimulated to produce secretin by-
(a) Cholecystokinin
(b) Bile juice
(c) Acid in chyme
(d) Gastrin
Answer
Question 8.
Crypts of Lieberkuhn involved in:
(a) Secretion of succus entericus
(b) Secretion of rennin
(c) Secretion of ptyalin
(d) digestion of food
Answer
Answer: (a) Secretion of succus entericus
Question 9.
The cells of the epithelial lining in the vertebrate stomach are not damaged by HCl because of
(a) Mucus secretion covering the epithelium
(b) Neutrilizatioin of HCl by alkaline gastric juice.

(c) HCl being to dilute
(d) Epithelium being resistant to HCl
Answer
Answer: (a) Mucus secretion covering the epithelium
Question 10.
Lower jaw composed of in Rabbit:-
(a) Dentary
(b) Maxilla
(c) Premaxilla
(d) Palatine
Answer
Answer: (a) Dentary
Question 11.
Bacteria entering with contaminated food are killed in stomach by
(a) Pepsin
(b) Renin
(c) Sodium bicarbonate
(d) HCl
Answer
Answer: (d) HCl
Question 12.
Deficiency of Vitamin A causes:
(a) Retarted growth
(b) Scurvy
(c) Beri-Beri
(d) Rickets
Answer
Answer: (a) Retarted growth
Question 13.
Bilirubin and bilivirdin are found in
(a) Blood
(b) Bile
(c) Saliva
(d) None of the Above
Answer
Answer: (b) Bile
Question 14.
Which reserve a starving man first consumes

(a) Fat
(b) Protein
(c) Glycogen
(d) Vitamin
Answer
Answer: (c) Glycogen
Question 15.
Enzyme maltase in human gut acts on food at a pH of
(a) More than seven to change starch into maltose.
(b) Less than 7 to change starch into maltose.
(c) More than 7 to change maltose into glucose.
(d) Less than 7 to change maltose into glucose.
Answer
Answer: (c) More than 7 to change maltose into glucose.
Question 16.
Total no. of incisor teeth in rabbit is
(a) 8
(b) 6
(c) 10
(d) 4
Answer
Answer: (b) 6
Question 17.
Which is sweet in taste but is not sugar-
(a) Starch
(b) Saccharine
(c) Lactose
(d) Protein
Answer
Answer: (b) Saccharine
Question 18.
Which one is not an enzyme of digestive system
(a) Enterokinase
(b) Amylase
(c) Trypsin
(d) Enterogastrin
Answer
Answer: (d) Enterogastrin

Question 19.
Enamel of teeth is secreted by:
(a) Ameloblast
(b) Odontoblast
(c) Osteoblast
(d) Osteoclast
Answer
Answer: (a) Ameloblast
Question 20.
Hydrochloric acid is secreted by the:
(a) Paneth cells
(b) Goblet cells
(c) Chief cells
(d) Parietal cells
Answer
Answer: (d) Parietal cells
Question 21.
Ptyalin cannot work in stomach, because it becomes-
(a) Inactive due to HCl
(b) Inactive due to Renin
(c) Inactive due to Pepsin
(d) None of these
Answer
Answer: (a) Inactive due to HCl
Question 22.
To keep people healthy, strong and energetic and long-lived, it is necessary to provide them-
(a) High energy food
(b) Large amount of food
(c) Balanced diet
(d) Initiative and spirit
Answer
Answer: (c) Balanced diet
Question 23.
The structure which prevents entry of food into windpipe during swallowing in mammals is
(a) Larynx
(b) Glottis

(c) Epiglottis
(d) Pharynx
Answer
Answer: (c) Epiglottis
Question 24.
The most common concentrated source of proteins for vegetarians in our country is-
(a) Potatoes
(b) Meat
(c) Eggs
(d) Pulses
Answer
Answer: (d) Pulses
Question 25.
Secretion of pancreatic juice is stimulated by
(a) Gastrin
(b) Secretin
(c) Enterogastrone
(d) Enterokinase
Answer
Answer: (b) Secretin
Question 26.
Which of the following is a common passage in swallowing food and breathing-
(a) Pharynx
(b) Larynx
(c) Glottis
(d) Gullet
Answer
Answer: (a) Pharynx
Question 27.
Succus entericus is secreted by-
(a) Gastric glands
(b) Islets of langerhans
(c) Crypts of lieberkuhn & Brunner's gland
(d) Goblet cells
Answer
Answer: (c) Crypts of lieberkuhn & Brunner's gland

Question 28.
Vitamins are:
(a) Inorganic substances and can't be synthesized by animals.
(b) Inorganic substances and can be synthesized by animals.
(c) Organic substances which cannot mostly be synthesized by animals.
(d) Organic substances which can mostly be synthesized by animals.
Answer
Answer: (c) Organic substances which cannot mostly be synthesized by animals.
Question 29.
Parietal cells of mucosa in stomach is secrets
(a) Mucin
(b) Pepsin
(c) Dilute HCl
(d) All of the Above
Answer
Answer: (c) Dilute HCl
Question 30.
The function of enterogasterone hormone is:
(a) to control excretion
(b) to inhibit gastric juice secretion
(c) regulate the absorption of food
(d) to stimulate gastric glands to release gastric juice
Answer
Answer: (b) to inhibit gastric juice secretion
Question 31.
Meat, milk and egg mainly supply us with
(a) Hormones
(b) Carbohydrates
(c) Proteins
(d) Fats
Answer
Answer: (c) Proteins
Question 32.
Night blindness is caused due to deficiency of Vitamin
(a) B
(b) C
(c) D
(d) A

Answer
Answer: (d) A
Question 33.
Vitamin promoting wound healing is:
(a) B
(b) A
(c) D
(d) C
Answer
Answer: (d) C
Question 34.
Excess amino acids are deaminated & converted into urea in
(a) Kidneys
(b) liver
(c) Spleen
(d) Pancreas
Answer
Answer: (b) liver

Solutions for Class 11 Biology Chapter 16 Digestion and Absorption:

Section Name	**Topic Name**
16	Digestion and Absorption
16.1	Digestive System
16.2	Digestion of Food
16.3	Absorption of Digested Products
16.4	Disorders of Digestive System
16.5	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1. Choose the correct answer among the following:
(a) Gastric juice contains
(i) pepsin, lipase and rennin
(ii) trypsin, lipase and rennin
(iii) trypsin, pepsin and lipase

(iv) trypsin, pepsin and rennin.
(b) Succus entericus is the name given to
(i) a junction between ileum and large intestine
(ii) intestinal juice
(iii) swelling in the gut
(iv) appendix.
Solution: (a) (i) Pepsin, lipase and rennin
(b) (ii) Intestinal juice

2. Match column I with column II.

Column I	Column II
(a) Bilirubin and	(i)Parotid biliverdin
(b) Hydrolysis of	(ii)Bile starch
(c) Digestion of fat	(iii)Lipases
(d) Salivary gland	(iv) Amylases

Solution: (a), – (ii),- (b) – (iv), (c) – (iii),- (d) – (i)

3. Answer briefly:
(a) Why are villi present in the intestine and not in the stomach?
(b) How does pepsinogen change into its active form ?
(c) What are the basic layers of the wall of alimentary canal?
(d) How does bile help in the digestion of fats ?
Solution: (a) The absorptive surface area of small intestine is enormously increased by microvilli and as maximum absorption
of digested food takes place in small intestine as compared to other organs, therefore, villi are present in small intestine and not in stomach. Moreover, stomach is primarily associated with temporary storage of food.
(b) The proenzyme pepsinogen, on exposure to hydrochloric acid, secreted by oxyntic cells of gastric glands gets converted into the active enzyme pepsin, the proteolytic enzyme of the stomach.
(c) The wall of alimentary canal from oesophagus to rectum possesses four layers, namely serosa, muscularis, sub-mucosa and mucosa. Serosa is the outermost layer and is made up of a thin mesothelium with some connective tissues. Muscularis is formed by smooth muscles. The sub-mucosal layer is formed of loose connective tissues containing nerves, blood and lymph vessels. In duodenum, glands are also present in sub-mucosa. The innermost layer lining the lumen of the alimentary canal is the mucosa. This layer forms irregular folds (rugae) in the stomach and small finger¬like foldings called villi in the small intestine.

(d) Bile has no enzymes but contains bile salts, namely, sodium bicarbonate, sodium glycocholate and sodium taurocholate that reduce the surface tension of large fat droplets and break them into many small droplets by a process known as emulsification. These small fat droplets present large surface area for lipase (fat digesting enzyme) to act upon them. Moreover, bile also activates lipases.

4. State the role of pancreatic juice in digestion of proteins.

Solution: The pancreatic juice contains inactive enzymes – trypsinogen, chymotrypsinogen, procarboxypeptidases. Trypsinogen is acti¬vated by an enzyme enterokinase, (secreted by the intestinal mucosa) into active trypsin, which in turn activates the other enzymes of the pancreatic juice. Proteins, proteoses and peptones (partially hydrolysed proteins) in the chyme reaching the intestine are acted upon by these proteolytic enzymes of pancre¬atic juice.

$$\left.\begin{array}{l}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{array}\right] \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin/ Chymotrypsin}} \left[\begin{array}{l}\text{Oligopeptides}\\ \text{and}\\ \text{Dipeptides}\end{array}\right.$$

5. Describe the process of digestion of protein in stomach.

Solution: The gastric glands of the stomach secrete gastric juice that contains HCl and proenzymes – pepsinogen and prorennin. The proenzyme pepsinogen, on exposure to HCl gets converted into the active enzyme pepsin, the proteolytic enzyme of stomach. The pepsin converts proteins into proteoses and peptones (peptides). Prorennin is found in gastric juice of infants and is activated by pepsin into active rennin. It helps in digestion of milk protein casein.

$$\text{Pepsinogen} \xrightarrow{\text{HCl}} \text{Pepsin}$$

$$\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Proteoses and peptones}$$

$$\text{Prorennin} \xrightarrow{\text{HCl}} \text{Rennin}$$

$$\text{Casein (Milk protein)} \xrightarrow{\text{Rennin}} \text{Paracasein}$$

$$\begin{array}{l}\text{Paracasein}\\ +\text{Ca}\end{array} \longrightarrow \begin{array}{l}\text{Calcium paracaseinate}\\ \text{(curd)}\end{array}$$

$$\text{Calcium paracaseinate} \xrightarrow{\text{Pepsin}} \text{Peptones}$$

6. Give the dental formula of human beings.

Solution: The dental formula of human beings is

$$\frac{2123}{2123} \text{ i.e. } i\frac{2}{2},\ c\frac{1}{1},\ pm\frac{2}{2},\ m\frac{3}{3}=16$$

It shows arrangement of teeth in each half of the upper and lower jaw.

$$\text{or} \quad \frac{2+1+2+3}{2+1+2+3}\times\frac{2}{2}=\frac{16}{16} \text{ or } 32.$$

7. Bile juice contains no digestive enzymes, yet it is important for digestion. Why ?

Solution: Bile has no enzymes but contains bile salts, namely, sodium bicarbonate, sodium glycocholate and sodium taurocholate that reduce the surface tension of large fat drop¬lets and break them into many small droplets by a process known as emulsification. These small fat droplets present large surface area for lipase (fat digesting enzyme) to act upon them. Moreover, bile also activates lipases.

$$\text{Fat (triglyceride)} \xrightarrow{\text{Bile}} \text{Emulsified fat}$$

8. Describe the digestive role of chymotrypsin. Which two other digestive enzymes of the same category are secreted by its source gland ?

Solution: Chymotrypsin is a proteolytic enzyme of pancreatic juice secreted by exocrine part of pancreas. It helps in digestion of proteins. It converts proteins, peptones and proteoses into oligopeptides and dipeptides. Two other proteolytic enzymes present in pancreatic juice are trypsinogen and procarboxypeptidase.

9. How are polysaccharides and disaccharides digested ?

Solution: Digestion of polysaccharides (starch and glycogen) starts from buccal cavity. In buccal cavity, polysaccharides are acted upon by salivary amylase or ptyalin which splits starch and glycogen into disaccharides and small dextrins called 'α' dextrin.

$$\text{Starch and Glycogen} \xrightarrow[\text{pH - 6.8}]{\text{Salivary amylase}} \text{Maltose + Isomaltose + 'α' dextrins.}$$

The digestion of carbohydrates does not occur in stomach because gastric juice itself has no carbohydrase.

In small intestine, the food mixes with two juices, pancreatic juice and intestinal juice. Pancreatic juice contains a carbohydrase named pancreatic amylase. This enzyme hydrolyses more starch and glycogen.

Starch and Glycogen $\xrightarrow[\text{amylase}]{\text{Pancreatic}}$ Maltose + Isomaltose + α dextrins.

Intestinal juice contains carbohydrases; maltase, isomaltase, a-dextrinase, sucrase and lactase which act on disaccharides as follows:

Maltose $\xrightarrow{\text{maltase}}$ Glucose + Glucose

Isomaltose $\xrightarrow{\text{isomaltase}}$ Glucose + Glucose

'α' dextrins $\xrightarrow{\alpha\text{-dextrinase}}$ Glucose + Glucose

Sucrose $\xrightarrow{\text{sucrase}}$ Glucose + Fructose

Lactose $\xrightarrow{\text{lactase}}$ Glucose + Galactose

fructose and galactose are monomers of carbohydrates. These are absorbed by intestinal mucosa.

10. What would happen if HCl were not secreted in the stomach?

Solution: HCl is secreted by parietal or oxyntic cells of gastric glands. It serves the following functions:

1. It activates the pepsinogen and prorennin into their active form pepsin and rennin.
2. It provides the acidic pH (pH 1.8) optimal for pepsin.
3. It kills the harmful bacteria present in the food.
4. It stops the action of saliva on food. Pepsin and rennin are the principle proteolytic enzymes of stomach. If these enzymes are not activated by HCl then digestion of protein will not take place in stomach, and also the harmful bacteria can cause various diseases.

11. How does butter in your food get digested and absorbed in the body ?

Solution: Butter is a saturated fat. Fats and oils of the ingested food are triglycerides.

They are digested by lipases. Small intestine is the principal organ for fat digestion.

In the small intestine food meets three secretions, bile, pancreatic juice and intestinal juice, all alkaline in nature.

Bile contains no enzyme but it contains bile salts which reduces the surface tension of large fat droplets and breaks them into smaller ones (emulsification).

Triglycerides $\xrightarrow{\text{Bile salts}}$

Emulsified triglycerides Pancreatic juice contains pancreatic lipase, which is the principal fat digesting enzyme. It is activated by bile.

$$\text{Emulsified triglyceride} \xrightarrow{\text{Lipase}} \text{Fatty acid + Diglyceride}$$

$$\text{Diglyceride} \xrightarrow{\text{Lipase}} \text{Fatty acid + Monoglyceride}$$

$$\text{Monoglyceride} \xrightarrow{\text{Lipase}}$$

Fatty acid + Glycerol Intestinal lipase found in intestinal juice hydrolyses some triglycerides, diglycerides and monoglycerides to fatty acids and glycerol like pancreatic lipase.

Fatty acids, glycerol and monoglycerides are the end products of fat digestion and being insoluble in water cannot be directly absorbed from the intestinal contents. So they combine with the bile salts and phospholipids to form micelles (water soluble). From the micelles fatty acids, glycerides, sterols and fat soluble vitamins are absorbed into the intestinal cells by diffusion where they are resynthesised in the ER and are converted into very small protein coated fat molecules (droplets) called chylomicrons. The latter are released from the intestinal cells into the lymph present in the lymphatic capillaries, the lacteals. These lacteals ultimately release the absorbed substances into the blood stream.

12. Discuss the main steps in the digestion of proteins as the food passes through different parts of the alimentary canal.

Solution: Proteins of ingested food are broken down into amino acids by proteases (peptidases). Proteases are secreted in inactive forms called proenzymes which are converted into active forms at site of their action. Protein digestion starts in the stomach and is completed in the small intestine. Saliva contains no protease.

Digestion of proteins in stomach : Chief cells of gastric gland secrete pepsinogen and prorennin, which act as follows:

$$\text{Pepsinogen} \xrightarrow{\text{HCl}} \text{Pepsin}$$

$$\text{Proteins} \xrightarrow{\text{Pepsin}}$$

$$\text{Prorennin} \xrightarrow{\text{HCl}} \text{Rennin}$$

$$\text{Casein (Milk protein)} \xrightarrow{\text{Rennin}} \text{Paracasein + Whey proteins}$$

$$\text{Paracasein + Calcium} \rightarrow \text{Calcium paracaseinate}$$

$$\text{Calcium paracaseinate} \xrightarrow{\text{Pepsin}} \text{Peptones}$$

Digestion of proteins in small intestine: In small intestine, peptones and proteoses are acted upon by enzymes of pancreatic juice and intestinal juice.
Pancreatic juice contains 3 inactive proteases; trypsinogen, chymotrypsinogen and pro-carboxypeptidase. Their action is as follows:

$$\text{Trypsinogen} \xrightarrow{\text{Enterokinase of intestinal juice}} \text{Trypsin}$$

$$\text{Peptones + proteoses} \xrightarrow{\text{Trypsin}} \text{Large peptides}$$

$$\text{Chymotrypsinogen} \xrightarrow{\text{Trypsin}} \text{Chymotrypsin}$$

$$\text{Proteoses + Peptones} \xrightarrow{\text{Chymotrypsin}} \text{Large peptides}$$

$$\text{Procarboxypeptidase} \xrightarrow{\text{Trypsin}} \text{Carboxypeptidase}$$

$$\text{Large peptides} \xrightarrow{\text{Carboxypeptidase}}$$

Dipeptides + Amino acids Intestinal juice contains two digestive pro-teases; aminopeptidases and dipeptidases and a nondigestive enterokinase (enteropeptidase).

$$\text{Large peptides} \xrightarrow{\text{Aminopeptidases}} \text{Dipeptides + Amino acids}$$

$$\text{Dipeptides} \xrightarrow{\text{Dipeptidases}} \text{Amino acids}$$

Amino acids are the end products of protein digestion which are absorbed by intestinal cells.

13. Explain the term thecodont and diphyodont.

Solution: Thecodont: In human, each tooth is embedded in a socket of jaw bone. Such teeth are described as thecodont.
Diphyodont: Majority of mammals including human beings form two sets of teeth

during their life, a set of temporary milk or deciduous teeth replaced by a set of permanent or adult teeth. This type of dentition is called diphyodont.

14. Name different types of teeth and their number in an adult human.

Solution: Adult human has 32 teeth with the

dental formula $\frac{2123}{2123}$.

Human has heterodont dentition i.e., having four different types of teeth. The number of different types of teeth in human are as follows:incisors = 8, canines = 4, premolars = 8, molars = 12

15. What are the functions of liver?

Solution: Liver is the largest gland of the body and consists of hepatic cells. Besides being a digestive gland, the liver performs a number of functions for the welfare of body. Its varied functions are as follows

1. Secretion of bile.
2. Glycogenesis, gluconeogenesis and glycogenolysis.
3. Storage of fat, glycogen, vitamins like A, D, E, K and B_{12}, blood, water, etc.
4. Deamination of amino acids.
5. Synthesis of urea.
6. Elimination of excretory substances.
7. Detoxification of harmful substances.
8. Formation and breakdown of blood
   corpuscles, i.e., in embryos, liver is haemopoietic (produces red blood corpuscles) and in adults its Kupffer cells phagocytise and destroy worn out and dead RBCs.
9. Secretion of blood proteins, i.e., prothrombin and fibrinogen.
10. Secretion of anticoagulant heparin.
11. Production of heat.
12. Secretion of enzymes.

Breathing and Exchange of Gases Class 5 Notes Biology

Cells continuously use oxygen (O_2) for the catabolic reactions that releases energy from molecules, e.g., breakdown of nutrient molecules like glucose. Thus, O_2 has to be provided to the cells constantly. Simultaneously, these reactions releases carbon dioxide (CO_2), which is harmful, so it must be removed quickly and efficiently.
The process that helps in the exchange of O_2 from the atmosphere with CO_2 produced by the cells is called breathing, commonly known as respiration.

Topic 1 Respiration : Types and Respiratory Organs

Respiration is a biochemical process that exchanges environmental oxygen with the CO_2 produced in the cells. It include stepwise oxidation of food in cells with intake of oxygen and elimination of CO_2 produced in oxidation, release of energy during oxidation and storing it in form of ATP.

Types of Respiration
Mechanism of respiration vary, depending mainly on an animal's habitat and levels of organisation.
The different types of respiration are
1. Aerobic Respiration
When oxygen is used for respiration, its called aerobic respiration. The organism undergoing the process are termed as aerobes.

The term breathing and respiration are not same. Breathing is the first step of respiration and a physical process, while respiration is a biochemical process involving exchange of gases and oxidation of food.
Inspiration is an active process, while expiration is a passive process.

2. Anaerobic Respiration
It occurs in the absence of molecular oxygen in the cytoplasm (also called as fermentation). It yields only about 5% of the food's energy. The organisms undergoing the process are called anaerobes, e.g., yeasts oxidise glucose to ethanol and CO_2.

- Anaerobic respiration appeared first in primitive atmosphere due to absence of oxygen there.
- In frog 100% cutaneous respiration occurs during hibernation and in all marine snakes, 20% respiration is by skin.
- Respiration is a catabolic process. It breaks organic molecules and release their bond energy. It occurs in all organisms, at all times.

Respiratory Organs

Different animal groups have evolved different mechanism of breathing for the exchange of gases.
Lower animal like sponges, cnidarians, Platyhelminthes and free-living roundworms exhange 02 by simple diffusion through body surface.

Special vascularised structures called gills are used by most of the aquatic arthropods and molluscs whereas, vascularised bags called lungs are used by the terrestrial forms for the exchange of gases.

Parasitic flatworms (e.g.. Tapeworms) and roundworms (e.g., Ascaris) have anaerobic mode of respiration.
Human Respiratory System

Human respiratory system may be divided into two major components, i. e., conducting portion and respiratory or exchanging portion.

Conducting Portion
It is the passage for the air (transports the atmospheric air to alveoli and return

from lungs to the exterior). This portion clear air from foreign particles, humidifies it and also brings it to body temperature. In this part, gaseous exchange does not take place. It is also called dead air space. It starts with the external nostrils upto the terminal bronchioles.

The various parts are as follows

(i) External Nares (Nostrils) These are a pair of slits at the lower end of the nose, which opens into the the nasal chamber through the nasal passage.

(ii) Nasal Chambers Pair of passage located at the back of nostrils just above the mouth cavity. Nasal septum is a median partition that separates the two chambers.

Each chamber has three regions, i.e., Vestibular, respiratory and olfactory. The chambers has special pseudostratified ciliated epithelium by which air is filtered (by hairs) and moistened (by mucus).

(iii) Internal Nares These are the posterior openings of the nasal chambers that leads into the nasopharynx.
(iv) Nasopharynx It is the upper part of pharynx, into which internal nares open.

(v) Larynx It is the upper part of trachea. It allows the air to pass into lungs. Nasopharynx opens through glottis of the larynx into trachea. Glottis is a slit-like aperture that remains open except during swallowing.

The glottis bears a leaf-like cartilaginous flap, the epiglottis at its anterior region. It closes the glottis to check the entry of food during swallowing. Larynx helps in sound production and hence, called the sound box.
Larynx is often called the Adam's apple and is more prominent in men than in women.

(vi) Trachea It is a thin-walled tube, about 11cm long and 2.5 cm wide. It extends up to the mid-thoracic cavity. It passes the air to the alveoli.

(vii) Primary and Secondary Bronchi At the level of 5th thoracic vertebra, the trachea divides into two tubes, right and left primary bronchi.

Each bronchi further divides into lobar or secondary bronchi. The secondary bronchi sub-divides into smaller tertiary bronchi, which divide into still smaller bronchioles. The small terminal bronchioles give off a number of thin, irregular walled, vascular bag-like structure called alveoli.

Note:

- Wall of trachea, bronchi and bronchioles is composed of fibromuscular tissue and is lined by pseudostratified ciliated columnar epithelium rich in mucus secreting cells.
- Cartilaginous rings support the walls of the trachea and the bronchi to prevent their collapsing.

Respiratory/Exchanging Portion

The alveoli and their ducts form this part of the respiratory system. It is the site of actual diffusion of O_2 and CO_2 between blood and atmospheric air. The branching network of bronchi, bronchioles and alveoli comprises the lungs, which provide the surface for exchange of gases in humans.

Lungs

These are the paired triangular bags that constitute the respiratory organ.

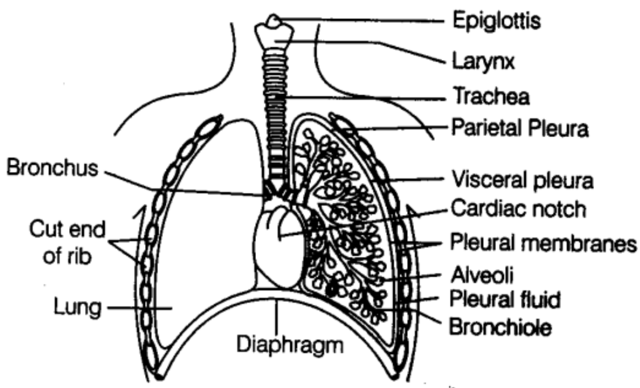


Fig. 17.1 Diagrammatic view of human respiratory system (sectional view of the left)

They lie in the thoracic cavity on the sides of the heart. The thoracic cavity is enclosed dorsally by thoracic vertebrae, laterally by the ribs, ventrally by the sternum and closed below by a dome-shaped diaphragm.

The arrangement of lungs is such that, any change in the volume of thoracic cavity will be manifested in the lung (pulmonary) cavity. This arrangement is necessary for breathing as the pulmonary volume cannot be altered directly.

Protective Coats (Pleurae)
Each lung is enclosed in two membranes called the pleura (layers of peritoneum of the thorax). The inner membrane, called the visceral pleuron, which is firmly bound to the surface of lungs. The outer membrane, called the parietal pleuron is held to the thoracic wall and diaphragm by connective tissue. Pleural cavity is a very narrow space that exists between the two pleura. It contains the pleural fluid secreted by the pleura, for reducing friction on the lung surface.

External Features
(a) The left lung has two lobes, i.e., superior lobe and inferior lobe separated by oblique fissure. It has a cardiac notch, a concavity where the heart lies. It is longer and narrower than right lung.
{b) The right lung is bigger and has three lobes, i.e., superior lobe, middle lobe and inferior lobe separated by horizontal fissure and oblique fissure.

Note:

- There are about 300 million alveoli in the two lungs with a combined surface area of about 70 m^2.
- A film of lecithin lines the alveoli, that lowers the surface tension.
- Larynx is comprised of 9 cartilages (epiglottis, thyroid and cricoid are single, while arytenoid, comiculate and cuneiform are paired).
- If the chest wall is pierced (e.g., by a stab wound), atmospheric air rushes into the pleural cavity, eliminating the pressure difference across lung walls causing the lungs to collapse. The condition is called pneumothorax.

Topic 2 Respiration Processes : Breathing and Gaseous Exchange

The main mechanisms of respiration is categorised into following three steps
(i) Breathing (pulmonary ventilation) is the inflow of atmospheric air and release (outflow) of CO_2 rich alveolar air.
(ii) Exchange of gases (O_2 and CO_2) across alveolar membrane as well as in tissues.
(iii) Transport of gases by the blood.

Breathing
Breathing is an extracellular, energy consuming and physical process. It involves movement of thorax, expansion (inflation) and deflation of lungs and flow of air into and from the lungs by creating a pressure gradient between the lungs and the

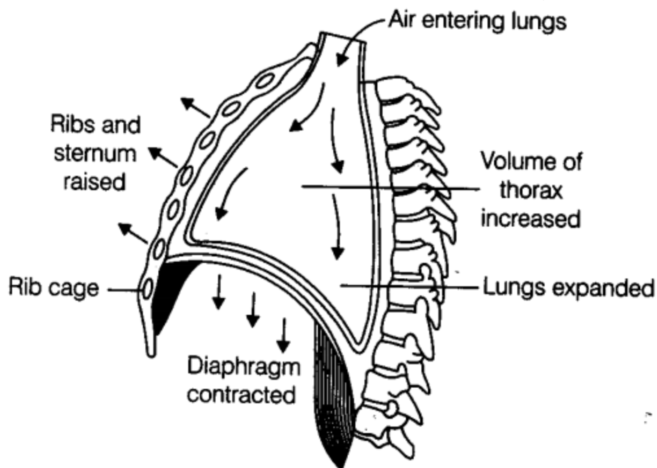
atmosphere.
The diaphragm and a specialised set of muscles, i.e., external and internal intercostals between the ribs help in generation of such gradients.

Breathing mainly involves two steps
i. Inspiration
It is an active process by which fresh air enters the lungs. It can occur if the pressure within the lungs (intra-pulmonary pressure) is less than the atmospheric pressure, i.e., negative pressure in lungs with respect to atmospheric pressure.

Following muscles play an important role
(a) Diaphragm It is lowered by the contraction of its muscle fibres and becomes flat. This causes an increase in the volume of thoracic chamber in the antero-posterior axis.

(b) External intercostal muscles They occur between the ribs (internal intercostal muscles are related to expiration). The external intercostal muscles contract and pull the ribs and the sternum upward and outward thus, increasing the volume of thoracic chamber in dorso-ventral axis.

Accessory muscles of breathing, i.e. scaleni, sternomastoid and ala nasi come into action during forced inspiration.
Thus, the overall increase in the volume of thoracic cavity causes an increase in pulmonary volume. As a result, there is a decrease in the intra-pulmonary pressure. The , greater atmospheric pressure outside the body now causes air to flow rapidly into external nares, which sequentially leads to alveoli.



(a)

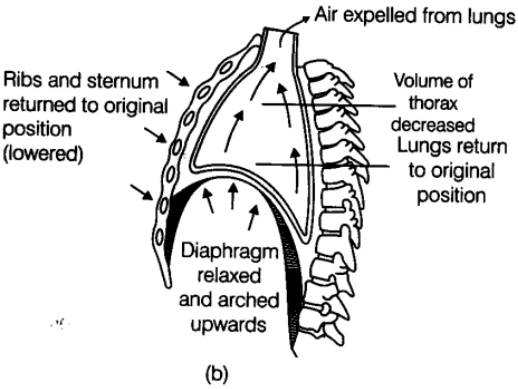


Fig. 17.2 Mechanism of breathing
(a) Inspiration (b) Expiration

ii. Expiration

It is a passive process by which CO_2 is expelled out from the lungs. It takes place when the intra-pulmonary pressure is higher than the atmospheric pressure.

The movement of muscles involved is as follows

(a) Diaphragm The muscle fibres of the diaphragm relax making it convex, decreasing volume of the thoracic cavity.

(b) Internal intercostal muscles These muscles contract thus, pulling the ribs downward and inward, decreasing the thoracic volume.

Abdominal muscles (i.e., external and internal oblique muscles) contracts, compressing the' abdomen and pushing the diaphragm up.

The overall volume of the thoracic cavity thus, decreases thereby reducing the pulmonary volume.

As a result, the intra pulmonary pressure increases slightly above the atmospheric pressure. This inturn causes the expulsion of the air from the lungs. The process of expiration is simpler than inspiration.

Note:

- At rest, breathing occurs about 12-16 times/minute, being more in children.
- The volume of air involved in breathing movements can be estimated by using a spirometer. It helps in clinical assessment of pulmonary functions.
- Breathing in frog is considered as positive pressure.

Respiratory Volumes and Capacities

The quantity of air the lungs can receive, hold or expel under different conditions are called respiratory (or pulmonary) volumes.
Combination of two or more pulmonary volumes are called respiratory (pulmonary) capacities.

The different volumes and capacities are as follows
(i) Tidal Volume (TV) It Ms the volume of air inspired or expired during normal breathing in relaxed or resting position. It is about 500 mL. It consists of 150 mL of dead space volume and 350 mL of alveolar volume.
A healthy man can inspire or expire approximately 6000-8000 mL of air per minute.

(vi) Expiratory Capacity (EC) It is the total volume of air a person can expire after a normal inspiration. It includes tidal volume and expiratory reserve volume.
EC= TV+ ERV

(vii) Functional Residual Capacity (FRC) It is the volume of air that will remain in the lungs after a normal expiration. It includes residual volume and expiratory reserve volume.
FRC= RV+ ERV

(viii) Vital Capacity (VC) It is the maximum value of air a person can breathe in after a forced expiration or the maximum volume of air a person can breathe out after a forced inspiration. This includes TV+ IRV+ ERV.
It varies from 3400-4800 mL depending upon age, sex and height of individual.

(ix) Total Lung Capacity It is the total volume of air present in the lungs after a forced (maximum) inspiration. It includes (VC+RV) or (RV+ ERV+ TV+ IRV)

Note:

- The vital capacity is higher in athletes, mountain dwellers than in plain dwellers, in men than women and in the young ones than in the old persons.
- All pulmonary volumes and capacities are about 20-25% less in women than in men and they are greater in tall persons and atheletes than in small and asthenic people.

- During respiration, the lungs and the respiratory tract are never devoid of air. Instead, there is a tidal volume of air.

Exchange of Gases

The primary sites for exchange of gases are the alveoli and tissues.
It occurs by simple diffusion mainly based on pressure/ concentration gradient.
The factors that affect rate of diffusion are
(i) Thinness of the membrane.
(ii) Surface area of the membrane.
(iii) Permeability of the membrane.
(iv) Solubility of the gases.
(v) Partial pressure gradient (difference) of gases on the two sides of a membrane between them.

Partial pressure of a gas is the pressure it exerts in a mixture of gases. It is equal to the total pressure of the mixture divided by percentage of that gas in the mixture.
1. Inspiratory Reserve Volume (IRV) It is the additional amount of air that can be inspired forcibly after a normal inspiration. It is about 2500-3000 mL of air.

2. Expiratory Reserve Volume (ERV) It is the additional volume of air that can be expired forcibly after a normal expiration. It is about 1000-1100 mL.

3. Residual Volume (RV) It is the volume of air remaining in the lungs even after a forcible expiration. It is about 1100-1200 mL. It can not be measured by spirometry.

4. Inspiratory Capacity (IC) It is the total volume of air a person can inspire after a normal expiration. It is about 2500-3000 mL. It includes tidal volume and inspiratory reserve volume.
IC= TV+ IRV

Partial Pressure (in mm Hg) of Oxygen and Carbon dioxide at different parts Involved in Diffusion in Comparison to those in Atmosphere

Respiratory Gas	Atmospheric Air	Alveoli	Blood (Deoxygenated)	Blood (Oxygenated)	Tissues
O_2	159	104	40	95	40
CO_2	0.3	40	45	40	45

i. Exchange of Gases between Alveoli and Blood

This exchange between lung alveoli and pulmonary capillaries is called external respiration.

The alveolar wall is very thin with a rich network of blood capillaries. It is also called as respiratory membrane or diffusion membrane.

It consists of three major layers, i.e., the thin squamous epithelium of alveoli, the endothelium of alveolar capillaries and the basement substance in between them.

All these layers form a membrane of about 0.2 mm thickness.

This membrane has a limit of gaseous exchange between alveoli and pulmonary blood, called the diffusing capacity.

At a particular pressure difference, the diffusion of CO_2 is 20-25 times faster than oxygen. Thus, the amount of CO_2 that can diffuse through the membrane per unit difference in partial pressure is much higher as corrtpared to oxygen.

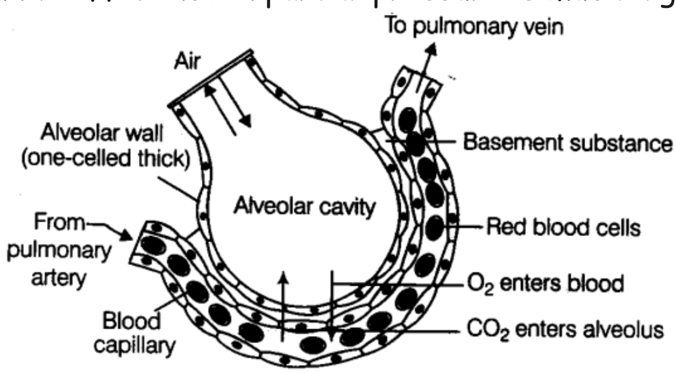


Fig. 17.3 A diagram of a section of an alveolus with a pulmonary capillary

As seen in the above table, pO_2 in the alveoli (104 mmHg) is higher than that in the deoxygenated blood in the capillaries of pulmonary arteries (95 mmHg). So, the movement of O_2 is from alveoli to the blood.

Also, pCO_2 is higher in deoxygenated blood (45 mmHg) than in alveoli, therefore, CO_2 passes from blood to the alveoli.

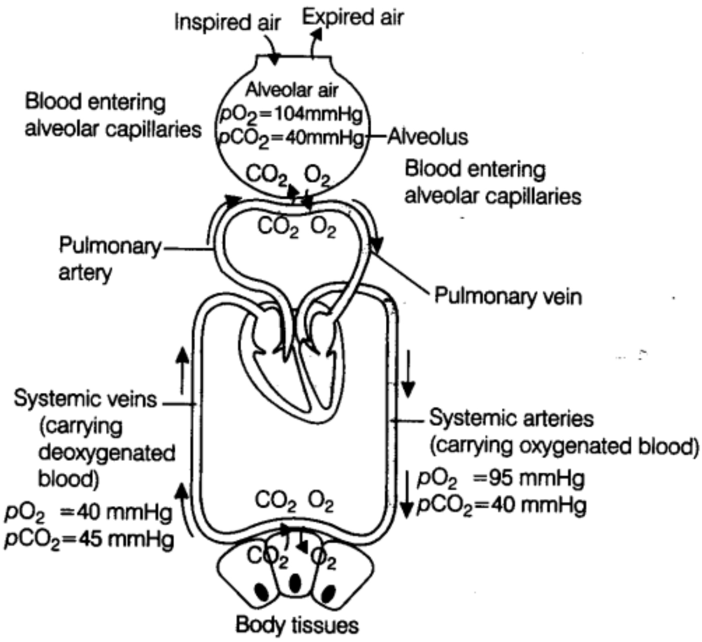


Fig. 17.4 Diagrammatic representation of exchange of gases at the alveolus and the body tissues with blood and transport of oxygen and carbon dioxide

ii. Exchange of Gases between Blood and Tissue Cells

This exchange between tissue blood capillaries and tissue cells is called internal respiration. pO_2 in oxygenated blood (95 mmHg) > pO_2 in body cells (40 mmHg) and pCO_2 in oxygenated blood (40 mmHg) < pCO_2 in body cells (45 mmHg).

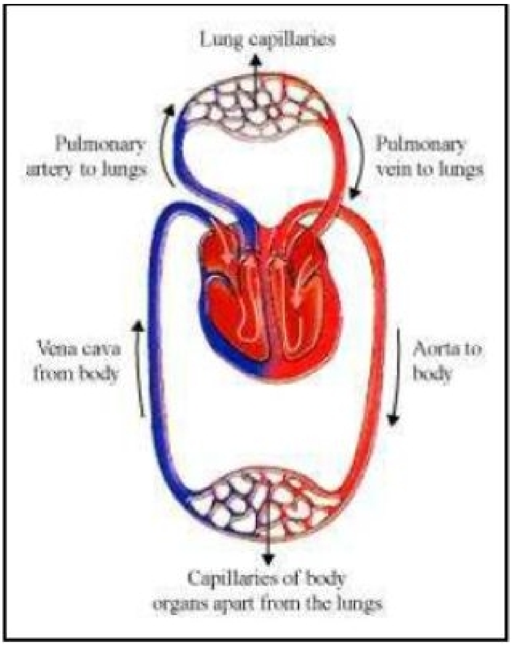
Due to this partial pressure differences, oxygen diffuses from the capillary blood to the body cells and CO_2 diffuses from the body cells to the capillary blood via tissue fluid. Now, the blood will become deoxygenated, which is further carried to the heart and finally to the lungs.

Breathing and Exchange of Gases Class 5 MCQs Questions with Answers

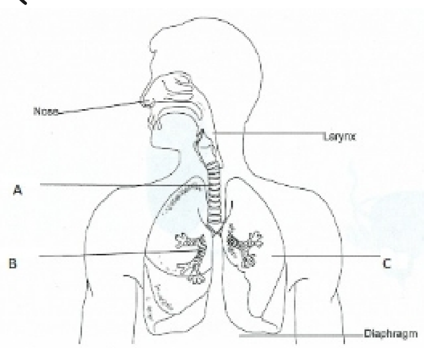
Question 1.
The function of pneumotaxic centre is
(a) regulate inspiration
(b) regulate rhythm
(c) increase heart rate
(d) all of the above
Answer

Answer: (a) regulate inspiration
Explanation:
Pneumotaxic centre lies in pons in the brain. It regulates inspiration.
Question 2.
Which one of the following is NOT correct?
(a) The nasal cavity warms and humidifies the air before it enters the lungs
(b) The right lung is composed of three lobes, but the left lung has only two lobes
(c) Lung volumes and vital capacity measure lung function.
(d) The visceral pleura is in direct contact with the chest wall.
Answer
Answer: (d) The visceral pleura is in direct contact with the chest wall.
Question 3.
_______ lies in front of esophagus.
(a) Trachea
(b) Glottis
(c) Larynx
(d) Epiglottis
Answer
Answer: (a) Trachea
Question 4.
In brain, respiratory control centre lies in
(a) pons
(b) medulla oblongata
(c) hypothalamus
(d) cerebrum
Answer
Answer: (b) medulla oblongata
Explanation:
Respiratory control centre or respiratory rhythm centre lies in medulla oblongata. Pneumotaxic centre which lies in pons region of the brain can moderate the functions of the respiratory rhythm centre.
Question 5.
Deoxygenated blood from heart comes to lungs via
(a) pulmonary vein
(b) systemic vein
(c) pulmonary artery
(d) systemic artery
Answer

Answer: (c) pulmonary artery
Explanation:

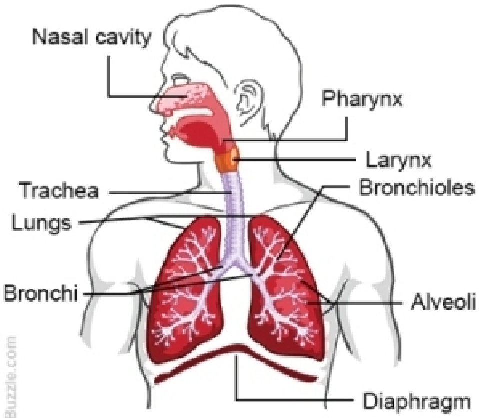


Question 6.



Label the parts of the human respiratory system.
(a) A- Oesophagus, B- Bronchioles, C- Lungs
(b) A- Trachea, B- Bronchioles, C- Lungs
(c) A- Trachea, B- Bronchus, C- Lungs
(d) A- Oesophagus, B- Bronchioles, C- Pleura
Answer

Answer: (c) A- Trachea, B- Bronchus, C- Lungs
Explanation:



Question 7.
Pleura is a layer covering
(a) heart
(b) kidneys
(c) lungs
(d) brain
Answer
Answer: (c) lungs
Explanation:
Double layered membrane called pleura, which covers lungs in human body.
Question 8.
Rheumatic fever can cause damage
(a) Alveoli of the Lungs
(b) heart valves
(c) heart muscles
(d) pleural membranes function
Answer
Answer: (b) heart valves
Question 9.
What protects the moist membranes of the respiratory tract?
(a) Mucus and cilia
(b) A c shaped cartilage rings
(c) A pebbly epidermal surface
(d) An acidic glands
Answer
Answer: (a) Mucus and cilia

Question 10.
RBCs, plasma and biocarbonate are the medium for transport of carbondioxide. Maximum amount of carbon dioxide is carried by
(a) RBCs
(b) Plasma
(c) Bicarbonates
(d) All RBCs and bicarbonate carried 70 per cent of carbondixide.
Answer
Answer: (c) Bicarbonates
Explanation:
20-25 per cent of carbondioxide is carried by RBCs.
70 per cent is carried as bicarbonate.
7 per cent is carried in a dissolved state through plasma.
Question 11.
The maximum volume of air that can be released from the lungs by forceful expiration after deepest inspiration is called the ______.
(a) Total lung capacity
(b) Vital capacity
(c) Tidal volume
(d) Ventilation rate
Answer
Answer: (b) Vital capacity
Question 12.
Which one of the followings is correct regarding larynx?
(a) It prevents foreign objects from entering the trachea
(b) It houses the vocal cords
(c) It is an organ made of cartilage and connects the pharynx to the trachea
(d) All of these are correct
Answer
Answer: (d) All of these are correct
Question 13.
Which of the following statements is true about Trachea in a respiratory system?
(a) It functions as passages of air to each alveolus
(b) It functions for sound production
(c) It Acts as passage of air to bronchi
(d) It Lowers the surface tension
Answer
Answer: (c) It Acts as passage of air to bronchi

Question 14.
Which of the following statement is true?
(a) Every 100 mL of deoxygenated blood delivers approximately 4 mL of carbondioxide to the alveoli.
(b) Every 100 mL of oxygenated blood delivers approximately 4 mL of oxygen to the tissues.
(c) Every 100 mL of oxygenated blood delivers approximately 4 mL of carbondioxide to the alveoli.
(d) Every 100 mL of deoxygenated blood delivers approximately 10 mL of carbondioxide to the alveoli.
Answer
Answer: (a) Every 100 mL of deoxygenated blood delivers approximately 4 mL of carbondioxide to the alveoli.
Explanation:
Every 100 mL of deoxygenated blood delivers approximately 4 mL of carbondioxide to the alveoli.
Every 100 mL of oxygenated blood delivers approximately 5 mL of oxygen to the tissues under normal physiological conditions.
Question 15.
Trachea divides into bronchi at
(a) 4th thoracic vertebra
(b) 5th thoracic vertebra
(c) 6th thoracic vertebra
(d) 7th thoracic vertebra
Answer
Answer: (b) 5th thoracic vertebra
Explanation:
Trachea is a straight tube extending up to the mid-thoracic cavity. It divides into bronchi at 5th thoracic vertebra.
Question 16.
Aerobic respiratory pathway is also termed as _______ pathway.
(a) Anabolic
(b) Catabolic
(c) Creatine phosphate
(d) Amphibolic
Answer
Answer: (d) Amphibolic

Question 17.
The oxygen dissociation curve is shifted to the right by an increase in _______.
(a) H+ concentration
(b) PCO_2
(c) temperature
(d) All of these
Answer
Answer: (d) All of these
Question 18.
The maximum volume of air contained in the lung by a full forced inhalation is called
(a) Vital capacity
(b) Tidal volume
(c) Total lung capacity
(d) Inspiratory capacity
Answer
Answer: (c) Total lung capacity
Question 19.
Which one of the following is NOT correct?
(a) The nasal cavity warms and humidifies the air before it enters the lungs
(b) The right lung is composed of three lobes, but the left lung has only two lobes.
(c) Lung volumes and vital capacity measure lung function.
(d) The visceral pleura is in direct contact with the chest wall.
Answer
Answer: (d) The visceral pleura is in direct contact with the chest wall.
Question 20.
Which organ lies in thoracic cavity?
(a) Heart
(b) Lungs
(c) Pancreas
(d) Both 1and 2
Answer
Answer: (d) Both 1 and 2
Explanation:
Lungs and heart both resides in thoracic cavity.

Solutions for Class 11 Biology Chapter 17 Breathing and Exchange of Gases:

Section Name	**Topic Name**
17	Breathing and Exchange of Gases

17.1	Respiratory Organs
17.2	Mechanism of Breathing
17.3	Exchange of Gases
17.4	Transport of Gases
17.5	Regulation of Respiration
17.6	Disorders of Respiratory System
17.7	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1. Define vital capacity. What is its significance?

Solution: Vital capacity is defined as the maximum volume of air a person can breathe in after a forced expiration or the maximum volume of air a person can breathe out after a forced inspiration. It represents the maximum amount of air one can renew in the respiratory system in a single respiration. Thus, greater the vital capacity more is the energy available to the body.

2. State the volume of air remaining in the lungs after a normal breathing.

Solution: When a person breathes normally, the amount which remains in the lung after normal expiration, is called functional residual capacity. It is the sum of residual volume and the expiratory reserve volume (FRC = RV + ERV). It is about 2100 – 2300 mL of air.

3. Diffusion of gases occurs in the alveolar region only and not in the other parts of respiratory system. Why?

Solution: For efficient exchange of gases, respi: atory surface must have certain characteristics such as (i) it must be thin, me ist and permeable to respiratory gases (ii) it must have large surface area, (iii) it must be highly vascular. Only alveolar region has these characteristics. Thus, diffusion of gases occurs in this region only.

4. What are the major transport mechanisms for CO_2? Explain.

Solution: Nearly 20-25 percent of CO_2 is transported by haemoglobin of RBCs, 70 percent of it is carried as bicarbonate ion in
plasma and about 7 percent of CO_2 is carried in a dissolved state through plasma.

CO_2 is carried by haemoglobin as carbamino- haemoglobin. This binding is related to the partial pressure of CO_2.

5. What will be the p02 and pCO_2 in the atmospheric air compared to those in the alveolar air?
(i) pO_2 lesser, pCO_2 higher
(ii) pO_2 higher, pCO_2 lesser
(iii) pO_2 higher, pCO_2 higher
(iv) pO_2 lesser, pCO_2 lesser
Solution: (ii) Air that has entered the alveoli through the bronchioles is called alveolar air. It has the same partial pressure of CO_2 and 02 as is in the atmospheric air. Then, there occurs gaseous exchange between the adjacent blood capillaries and the alveoli. CO_2 diffuses from blood into the alveolar air and O_2 diffuses from alveolar air to the blood. As a result, new alveolar air has higher $pCO_2$and lesser pO_2, than the atmospheric air.

6. Explain the process of inspiration under normal conditions.
Solution: Inspiration is a process by which fresh air enters the lungs. The diaphragm, intercostal muscles and abdominal muscles play an important role. The muscles of the diaphragm and external intercostal muscles are principle muscles of inspiration. Volume of thoracic cavity increases by contraction of diaphragm and external intercostal muscles. During inspiration, relaxation of abdominal muscles also occurs which allows compression of the abdominal organs by diaphragm. Thus, overall volume of the thoracic cavity increases and as a result, there is a decrease of the air pressure in the lungs. The greater pressure outside the body now causes air to flow rapidly into the lungs. The sequence of air flow is.

7. How is respiration regulated?
Solution: Respiration is under both nervous and chemical regulation.
The respiratory centre in brain is composed of groups of neurons located in the medulla oblongata and pons varolii. The respiratory centre regulates the rate and depth of the breathing.
Dorsal respiratory group of neurons are located in the dorsal portion of the medulla oblongata. This group of neurons mainly causes inspiration.
Ventral group of neurons are located in the ventrolateral part of the medulla oblongata. These can cause either inspiration or expiration.
Pneumotaxic centre is located in the dorsal part of pons varolii. It sends signals to all the neurons of dorsal respiratory group and only to inspiratory neurons of

ventral respiratory group. Its job is primarily to limit inspiration. Chemically, respiration is regulated by the large numbers of chemoreceptors located in the carotid bodies and in the aortic bodies. Excess carbon dioxide or hydrogen ions mainly stimulate the respiratory centre of the brain and increases the inspiratory and expiratory-signals to the respiratory muscles. Increased CO_2 lowers the pH resulting in acidosis. The role of oxygen in the regulation of respiratory rhythm is quite insignificant.

8. What is the effect of pCO_2on oxygen transport?

Solution: Increase in pCO_2 tension in blood brings rightward shift of the oxygen dissociation curve of haemoglobin thereby decreasing the affinity of haemoglobin for oxygen. This effect is called Bohr's effect. It plays an important role in the release of oxygen in the tissues.

9. What happens to the respiratory process in a man going up a hill?

Solution: Rate of breathing will increase in order to supply sufficient oxygen to blood because air in mountainous region is deficient in oxygen.

10. What is the site of gaseous exchange in an insect?

Solution: Tracheae (Tracheal respiration) is the site of gaseous exchange in an insect. .

11. Define oxygen dissociation curve. Can you suggest any reason for its sigmoidal pattern?

Solution: The relationship between the partial pressure of oxygen (pO_2) and percentage saturation of the haemoglobin with oxygen (O_2)is graphically illustrated by a curve called oxygen haemoglobin dissociation curve (also called oxygen dissociation curve).

The sigmoidal pattern of oxygen haemoglobin dissociation curve is the result of two properties which play significant role in the transport of oxygen. These two properties are:

(i) Minimal loss of oxygen from haemoglobin occurs above p02 of 70-80 mm Hg despite significant changes in tension of oxygen beyond this. This is depicted by relatively flat portion of the curve.

(ii)Any further decline in p02 from 40 mm Hg causes a disproportionately greater release of oxygen from the haemoglobin. It results in the steeper portion of the curve and causes the curve to be sigmoid.

12. Have you heard about hypoxia? Try to gather information about it, and discuss with your friends.

Solution: Hypoxia is a condition of oxygen shortage in the tissues. It is of two types:

(i) Artificial hypoxia: It results from shortage of oxygen in the air as at high altitude. It causes mountain sickness characterised by breathelessnes, headache, dizziness and bluish tinge on skin.

(ii) Anaemic hypoxia: It results from the reduced oxygen carrying capacity of the blood due to anaemia or carbon monoxide poisoning. In both cases, less haemoglobin is available for carrying O_2.

13. Distinguish between

(a) IRV and ERV

(b) Inspiratory capacity and expiratory capacity.

(c) Vital capacity and total lung capacity.

Solution:

(a) Differences between IRV and ERV are as follows:

	IRV	ERV
(i)	It is the extra amount of air that can be inspired forcibly after a normal inspiration. Thus it is forced inspiration.	It is the extra amount of air that can be expired forcibly after a normal expiration. Thus it is forced expiration.
(ii)	It is about 2500 to 3000 mL of air.	It is about 1000 ml to 1100 mL of air.

(b)Differences between inspiratory capacity and expiratory capacity are as follows:

	Inspiratory capacity	Expiratory capacity
(i)	It is the total volume of air that can be inhaled after a normal expiration.	It is the total volume of air a person can expire after a normal inspiration.
(ii)	It includes tidal volume and the inspiratory reserve volume (IC = TV + IRV).	It includes tidal volume and expiratory reserve volume (EC = TV + ERV).
(iii)	It is about 3000 to 3500 mL of air.	It is about 1500 to 1600 mL of air.

(c) Differences between vital capacity and total lung capacity are as follows:

	Vital capacity	Total lung capacity
(i)	It is the amount of air which one can inhale and exhale with maximum effort.	It is the total amount of air present in the lungs and the respiratory passage after a maximum inspiration.
(ii)	It is the sum of tidal volume, inspiratory reserve volume and expiratory reserve volume (VC = TV + IRV + ERV). It varies from 4 – 4.6 litres in a normal adult person.	It is the sum of the vital capacity and the residual volume (TLC = VC + RV). It is 5100 to 5800 mL.

14. What is tidal volume? Find out the tidal volume (approximate value) for a healthy human in an hour.

Solution: Tidal volume is the volume of air inspired or expired with each normal breath. This is about 500 mL in an adult person. It is composed of about 350 mL of alveolar volume and about 150 mL of dead space volume. The alveolar volume consists of air that reaches the respiratory surfaces of the alveoli and engages in gas exchange. The dead space volume consists of air that does not reach the respiratory surfaces.

A healthy man can inspire or expire approximately 6000 to 8000 mL of air per minute. Therefore, tidal volume for a healthy human in an hour is 360 – 480 mL of air.

Body Fluids and Circulation Class 5 Notes Biology

Each and every cell of a multicellular organism require food, oxygen and vital components to survive. Simultaneously as a result of metabolism, cell also produces some useful and waste products. Substances that are useful, are transported to other cells, while harmful or waste substances are removed from the body. Thus, it is essential to have efficient mechanisms to move these substances to and from the cells.
To carryout these processes, a carrier inturn is required by the body cells, providing them with essential components (i.e., food, oxygen, etc) and that helps in the distribution of useful products and elimination of waste products. Thus, circulatory system is formed by the carrier, a fluid medium that circulates throughout the body and fulfils the need of the body cells.

Topic 1 Blood and Lymph

Simple organisms such as sponges and coelenterates are single-celled and are in direct contact with atmosphere, thus they do not require any circulatory system for this. They instead circulate water from their surroundings through their body cavities, facilitating the cells to exchange these substances.

In more complex organisms special fluids are used to transport these substances within the body.
Blood and lymph are the two types of fluids that act as a carrier in the body. Blood is a special connective tissue comprising of a fluid matrix, plasma and formed

elements. Plasma forms the fluid medium in which the blood cells (corpuscles) float and carryout important functions.

It forms about 30-32% of the total extracellular fluid. Total volume of blood in an adult person is about 5-5.5 L

Plasma
It is a straw coloured, viscous in nature, slightly alkaline aqueous solution. It forms about 55% of the blood.

Composition of Plasma
It is composed of many organic and inorganic substances, which includes 90-92% water and 6-8% solutes in it.
The solutes found in plasma are various ions (likeNa^+, Mg^{2+}, Ca^{2+},HCO_3^-, etc.), glucose, traces of other
sugars, plasma proteins, amino acids, hormones, cholesterol, other lipids, urea, other wastes and other organic acids.

Factors for clotting or coagulation of blood are also present actively in the plasma. Plasma without the blood clotting factors is called serum.

Plasma Proteins
Proteins found in plasma are the important as they are responsible for providing viscosity to the plasma. The major proteins found in plasma are fibrinogen serum, globulins serum and albumins.
Functions of Plasma

It performs various functions in the blood, these are as follows
(a) Helps in transport and uniform distribution of heat all over the body.
(b) Provides body immunity.
(c) Maintenance of blood pH.
(d) Provides prevention of blood loss.
(e) Fibrinogen help in blood clotting, globulin help in defense mechanism, albumin maintains osmotic balance.

Formed Elements
The formed elements or blood corpuscles includes erythrocytes, leucocytes and platelets.These constitute about 45% of the blood.

1. Erythrocytes (Red Blood Cells)
These are the most abundant of all cells found in the blood. They are red in colour due to the presence of a pigment called haemoglobin, which acts as an oxygen carrier. The formation of RBCs takes place in the red bone marrow in the adults.
Shape, Size and Structure

RBCs are biconcave, disc-shaped cells with the diameter of about 7-8 micron. The shape of RBC is slightly variable. As there are no cell organelles found in it, whole volume is filled with haemoglobin.
Camel and llama are exceptional among mammals in having oval RBCs.

Number
A healthy individual has about 12-16 gms of haemoglobin in every 100 mL of blood.

- In men, the average number of RBC is about 5-5.5 million per cubic millimeter (mm^3) of blood.
- In women, the average number is about 4.5-4. mm^3 of blood.

Note:
The number of RBCs may vary depending upon the health factors of an individual and altitude where they live.
Person who lives at 18,000 feet may have as many as (8.3 x 106 RBC/pL). If a fall in number of RBC occurs, the condition is called anaemia whereas, the increase in number is called polycythemia.

Lifespan of RBC
Total lifespan of RBC is 120 days. After which RBC becomes non-functional and gets destroyed.

Disintegration of RBC
The process of disintegration of RBC occurs in liver. The Kupffer’s cells of liver helps in complete disintegration process. The haemoglobin is disintegrated to release iron. Free iron is transported back to the bone marrow and the debris that

remains, forms two toxic pigments, i.e., bilirubin and biliverdin (as studied in chapter 16). The remaining membrane of RBC known as ghost (i.e., without haemoglobin) is transported to spleen, where it gets destroyed completely. Due to this reason, spleen is called graveyard of RBC.

2. Leucocytes (White Blood Cells)
These are known to be the most active and motile constituent of blood as well as lymph. They do not possess the red colour pigment (haemoglobin) in them, so, they are colourless in nature.

They are nucleated and are generally short lived. The number of WBCs are relatively lesser in number, about 6000-8000 mm3 of blood.

White blood cells or leucocytes are categorised into two main categories. Such as
i. Granulocytes
They contain granules and have regularly lobed nucleus in the cytoplasm.
The granulocytes are further sub-divided into three main types
(a) Neutrophils These are the most abundant cells (about 60-65%) of the total WBCs. They stain equally well with acidic as well as basic dyes, because they are neutral in nature. These are phagocytic cells that destroy foreign organisms entering the body.

(b) Eosinophils They are characterised by their bilobed nucleus. They are stained bright red in colour with acidic dye (due to the presence of numerous coarse granules in it) such as eosin. They are about 2-3% of total WBCs. They resist infections and are also associated with all allergic reactions. They also help in dissolving blood clot. They help to destroy the toxic substances present in the body.
During allergic conditions, the number of eosinophils increases in the body.

(c) Basophils They contain fewer coarse granules than the eosinophils and can be staioed with basic dyes such as, methylene blue. They are found least abundandy (0.8-1.0%) among WBCs. They secretes histamine, serotonin, heparin, etc., and are involved in inflammatory reactions.

Agranulocytes

They lack granules and have non-lobed, rounded or oval nucleus.

Agranulocytes are also further sub-divided into of two main types

(a) Lymphocytes These are smaller in size and have rounded nucleus. Lymphocytes are of further two types, i.e., B-cells and T-cells. Both of these (i.e., B and T-cells) are responsible for immune responses of the body.

(b) Monocytes These are largest of all types of WBCs but are fewer in number. Mature monocytes are known as macrophages. They helps to kill foreign particles.

Blood Platelets (Thrombocytes)

These are cell fragments produced from megakaryocytes (i.e., the special cells found in the bone marrow).

Structure

These are oval-shaped, disc-like cells found only in mammalian blood. These are devoid of nuclei.

Platelets contain mitochondria, Golgi bodies and some other structures such as granules, tubules, filaments of aetin and myosin, ADP, etc.

Number

Blood normally contains 1,50,000-3,50,000 platelets per cubic meter (mm3). A reduction in their number can lead to clotting disorders which will lead to excessive blood loss from the body.

Life Span

The life span of platelets is only about 7-12 days.

The formation of thrombocytes is called thrombopoiesis.

Function of Blood Platelets

Their main function in the body is to release a variety of substances, most of which are involved in coagulation or clotting of blood.

Differences between Red Blood Cells and White Blood Cells

Red Blood Cell	White Blood Cell
These are smaller in size and more numerous in number, *i.e.*, Number of RBCs per cubic millimeter of blood is 5 million.	These are larger in size and fewer in number, *i.e.*, Number of WBCs per cubic millimeter of blood is only 8000.
These are non-nucleated, biconcave disc like cells.	WBCs are nucleated and amoeboid cells and keep on changing their shape.
RBCs contain haemoglobin (respiratory pigment).	WBCs do not contain haemoglobin.
RBCs can not diffuse out through capillary wall.	WBCs can diffuse out through capillary walls.
RBCs help in gaseous transport.	WBCs help in killing bacteria and foreign particles.
RBCs settle together to form rouleaux (*i.e.*, stack over each other due to abnormal shape).	WBCs do not form rouleaux.

Blood Groups

Although blood of every human being appears to be similar in appearance but, it differs in certain aspects. The plasma membrane of RBCs contain certain glycoproteinaceous molecules known as antigens, which differ in different persons. Thus, providing them different blood groups.

Two important common types of blood grouping found in human beings are called universal donors. Whereas, the persons with blood AB can accept blood from any blood group (i.e., AB as well as A, B, and O). Hence, are called universal recipients.

1. ABO Grouping

It was reported by Karl Landsteiner that ABO blood grouping is based on the-presence or absence of antigen A or antigen B on the surface of RBCs (chemicals that can induce immune response). Similarly the plasma of different individuals contain two natural antibodies (which are proteins produced in response to antigens).
A, B and 0 blood groups were discovered by Landsteiner (1900). Blood group AB was discovered by de Castello and Steini (1902).

People with blood group A have the antigen A on the surface of their RBCs and have antibodies against antigen B in their plasma. While in the people having blood group B, the case is just vice-versa to blood group.

Apart from both these blood groups (i.e., A and B) people with blood group AB have both antigen A and B on their RBCs surface and no antibodies for either of the antigens in their plasma.

In people with blood group O, both antigen A and B are not present on their RBCs but they have antibodies against the plasma. This distribution of antigens and antibodies in the four blood groups (A, B, AB and O).

These can be well explained through the table given below

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	Anti-B	A, O
B	B	Anti-A	B, O
AB	A, B	Nil	AB, A, B, O
O	nil	Anti-A, B	O

2. Rh Grouping

Apart from the antigens discussed in the previous section, another antigen, known as Rh antigen (similar to the one present in Rhesus monkey) is also found on the RBCs surface in majority of humans (nearly about 80%). Individuals having Rh antigen are called Rh positive (Rh^+) and those without the Rh antigen are called Rh negative (Rh^-).

Rh group is mandatory to be matched before transfusion of blood. An Rh^- person if gets exposed to Rh^+ blood, will form specific antibodies against the Rh antigens.

Rh Incompatibility During Pregnancy

A special case of mismatching of Rh group or Rh incompatibility has been observed between the Rh^- blood of a pregnant mother with Rh^+ blood of the foetus (born out of a marriage between Rh- woman and a Rh^+ man).

In such a case, mother becomes sensitive, while carrying a Rh^+ baby in her womb. The reason is that some of the RBCs from the developing foetus enters into the blood stream of the mother during development. This causes the development of anti-Rh antibodies.

The Rh antigens of the foetus do not get exposed to the Rh^- blood of the mother in case of first pregnancy (because two blood remain separated by placenta).

However, during delivery of the first child, there occurs a possibility that maternal blood may get exposed to small amounts of Rh^+ blood from the foetus.

Hence, preparing antibodies against Rh antigens in her blood.

Thus, in case of her subsequent pregnancies, Rh^+ foetuses get exposed to the anti-Rh antibodies. These will leak into the blood of the foetus (Rh^+) and destroy foetal RBCs.

This could be fatal to the foetus or could cause severe anaemia and jaundice to the body. This is known as erythroblastosis foetalis.

In humans, during transfusion of blood, the blood of a donor has to be carefully matched to the blood of a recipient before transfusing, so as to avoid the problem of clumping (destruction of RBC).
A person with blood group O can donate blood to persons with any of the other blood group (i.e., either A, B, AB and O). Hence, are

This condition can be avoided by administering anti-Rh antibodies to the mother immediately after the delivery of the first child.

Rh factor was discovered by Landsteiner and Weiner (1940) after immunising the rabbits with the blood of a monkey (Macaca rhesus).

There are 30 or so known antigens on the surface of red blood cells that give rise to different blood groups, e.g., MN, etc.

Coagulation of Blood or Clotting of Blood
When an injury is caused, the wound does not continue to bleed for a long time and the blood usually stops flowing after sometime. It is the natuial property exhibited by the blood to check the excessive loss of blood from an injury or trauma.
Clotting of blood is a complex process that involves various steps for its completion.

Natural Anticoagulants
Normally, inside an intact blood vessel, the blood does not coagulate because of the presence of an active anticoagulants, i.e., heparin or antiprothrombins. Apart from this procoagulants are also present in the blood but in their inactive forms.

Haemophilia is a genetic disease, which is caused due to deficiency of prothrombin, fibrinogen and vitamin-K. In this condition, the blood does not clot if there is any injury.

Formation of a Clot

An injury or trauma causes, stimulation of platelets in the blood to release certain platelet factors which inturn activates the mechanism of coagulation or clotting. Thromboplastin, a lipoprotein helps in clot formation.

It occurs in following three steps

(i) Thromboplastin, helps in formation of an enzyme prothrombinase (which inactivates heparin) that converts the inactive plasma protein, i.e., prothrombin into its active form thrombin.

(ii) Thrombin thus, acts as a proteolytic enzyme to convert fibrinogen molecule (produced from the liver in the presence of vitamin-K) to form insoluble fibrin monomer.

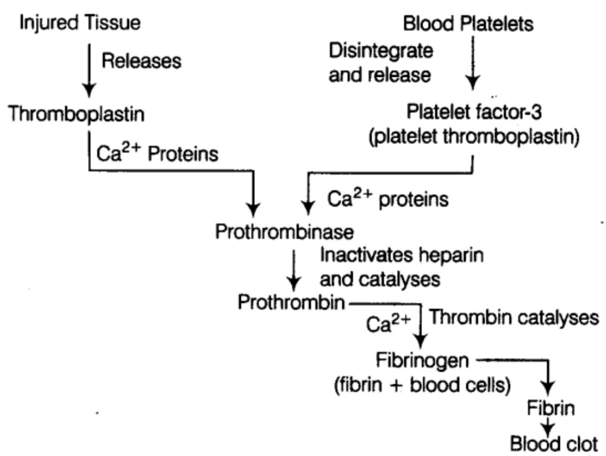


Fig 18.1 Clotting of blood

This reaction required thrombokinase an enzyme complex, which is formed by a series of linked enzymatic reactions (cascade process) which involves a number of various factors present in the plasma in their inactive state.

Both the changes mentioned above requires Ca^{2+} ions for their reaction.

(iii) These fibrin monomers polymerise to long, sticky fibres. The fibrin threads forms a fine network of threads called fibrins, in which dead and damaged formed elements of blood are trapped.

This finally leads to the formation of a clot or coagulum, which is a dark reddish brown scum formed over the surface of injury.
Certain factors released by tissues also help in initiating coagulation at the time of injury.

Functions of Blood

Blood performs the following important Junctions
(i) Helps in transportation of respiratory gases (i.e., O_2, CO_2, etc).
(ii) Helps in healing of wounds.
(iii) Maintains body pH, water and ionic balance. .
(iv) Fight against infections by forming body immunity.
(v) Also helps in transportation of hormones from endocrine glands to target organs.
(vi) Coagulation of blood.
(vii) Helps in transportation of body wastes from different body parts to kidneys.
(viii) Maintains normal body temperature.

Lymph (Tissue Fluid)

It is another fluid connective tissue that floats inside specialised vessels known as lymph vessels.

Composition

It is a colourless fluid containing high concentration of WBCs (specialised lymphocytes). The overall composition of lymph is similar to blood with the exception of absence of RBCs, platelets and some plasma proteins and in having less Ca and P than blood. It also contains all the ions, present in the blood plasma.

Lymphatic System

It is an elaborate network of vessels, which collects the interstitial fluid (tissue fluid), along with some protein molecules drains it back into the major veins. The lymphatic vessels are present in all tissues (except the central nervous system and cornea).

Formation of Lymph

As the blood passes through the capillaries of the arterial system into the tissues, some water along with many water soluble substances come out in the spaces between the cells of tissues.

But a very small amount of proteins come out from the capillary with the plasma (leaving the larger proteins and most of the formed elements in the blood vessel).

The fluid thus, released out is called interstitial fluid (tissue fluid) or Extra Cellular Fluid (ECF).
After entering the lymph vessel, the ECF becomes lymph.

Functions of Lymph
Lymph performes the following important functions
(i) It acts as an important carrier of nutrients, hormones, etc.
(ii) Absorption of fat also occurs through lymph in the lacteals present in the intestinal villi.
(iii) Also helps in the renewal of ECF.
(iv) Maturation of lymphocytes, i.e., B-cells and T-cells occur with the help of lymph nodes, releasing them into the lymph.
(v) Helps in keeping tissue cells moist.
The lymph first reaches the lymph nodes like thymus, tonsils, Payer's patches, spleen, etc., in the body.

Differences between Blood and Lymph

Blood	Lymph
It is red in colour due to the presence of haemoglobin in red cells.	It is colourless as red blood cells are absent.
It consists of plasma, RBC, WBC and platelets.	It consists of plasma and less number of WBC.
Glucose concentration is low.	Glucose concentration is higher than blood.
Clotting of blood is a fast process.	Clotting of lymph is comparatively slow.
It transports materials from one organ to other.	It transports materials from tissue cells into the blood.
Flow of blood is fast.	Lymph flows very slowly.
Its plasma has more proteins, calcium and phosphorus.	Its plasma has less protein, calcium and phosphorus.
It moves away from the heart and towards the heart.	It moves in one direction, *i.e.*, from tissues to sub-clavians.

Topic 2 Circulatory Pathways

It is already clear by the previous topic that blood and lymph are the important fluids in the body that acts as a carrier in transporting nutrients, hormones, etc.

Now, the question arises what makes this blood to circulate. So, the answer to this question lies in the fact that to circulate this blood throughout the body, a pump is required known as heart.

Depending upon the circulatory patterns in higher organisms the circulatory system are of the following two types

1. Open Circulatory System

It is the type of circulatory system in which blood pumped by the heart is passed through a vessel into the spaces or body cavities known as sinuses. From there the blood is collected by large veins, which opens into the heart.

In this type of system, the blood does not contain the respiratory pigment and if present, is dissolved in plasma.

This type of system is found in arthropods and molluscs.

There is no capillary system (i.e, interconnecting vessels) found in this type (i.e, open type) of circulatory system.

2. Closed Circulatory System

In this type of circulatory system, the blood pumped by the heart is always circulated inside the vessels {i.e., it is never present in large spaces or sinuses).From evolutionary point of view, this pattern is considered to be most advantageous as it supplies blood to the deepest tissues of the body. It is found in annelids and chordates.

Differences between Open and Closed Circulatory System

Open Circulatory System	Closed Circulatory System
The blood is pumped by the heart into the blood vessels that open into blood spaces (sinuses).	The blood is pumped by the heart into closed blood vessels.
Blood is in direct contact with the tissue cells.	Blood does not come in direct contact with the tissue cells.
Exchange of respiratory gases, nutrients and waste products occur directly between blood and tissues.	Exchange of respiratory gases, nutrients and waste products between tissues and blood occur *via* tissue fluid.
Blood returns to the heart slowly.	Blood returns to the heart rapidly.
The pressure of the blood is low.	The pressure of the blood is high.
Respiratory pigment, if present, is dissolved in blood plasma.	Respiratory pigment is present, and may be dissolved in plasma, but is usually held in red blood corpuscles.

Heart (The Pumping Organ in Vertebrates)

All vertebrates possess a muscular chambered heart.

Depending upon the different types of circulation in them heart is of following three types

1. Two-Chambered Heart

This is found in fishes mostly. It comprises of an atrium and a ventricle. During circulation of blood, the heart pumps out deoxygenated blood. This blood gets oxygenated by the gills and is then supplied to the body parts from where the deoxygenated blood is returned to the heart. Hence, the type of circulation is called single circulation.

2 Three-Chambered Heart

Amphibians and reptiles (except crocodiles) have a three-chambered heart. This type of heart comprises of two atria and a single ventricle.

During the circulation of blood, the left atrium receives the oxygenated blood from the gills/lungs/skin and the right atrium receives the deoxygenated blood from the other body parts. The blood gets mixed up in the single ventricle which further pumps out the mixed blood. This type of circulation- is called incomplete double circulation.

3 Felir-Chambered Heart

Crocodiles, birds and mammals possess this type of heart. It comprises of two atria and two ventricles. During the course of circulation, the oxygenated and deoxygenated blood is received by the left and the right atria respectively.

The blood from each atria are passed onto the ventricles of the same sides (i.e., left and right ventricles). Unlike, three-chambered heart, in which the bipod through the ventricles {i.e., four-chambered) is pumped out without any mixing {i.e., two separate circulatory pathways are present in these organisms). Hence, this type of circulation is called double circulation.

Human Circulatory System

Circulatory system in humans is also known as blood vascular system. It consists of a muscular chambered heart, a network of closed branching blood vessels and the fluid that is circulated, i.e., blood.

Position and Appearance

Heart is a mesodermally derived organ, situated in the thoracic cavity in between the two lungs. It appears to be slightly tilted towards the left side. It is a hollow, fibromuscular organ, slightly conical in shape of about 12 cm length and 9 cm breadth. The upper broad part is called the base and the lower narrow part known as the apex. It has a size of a clenched first.

Protective Covering

The heart is protected by a double walled membranous sac or a bag called pericardium, enclosing pericardial fluid. This pericardial fluid helps in keeping the surface of the heart moist, so as to protect it from shock and mechanical injuries and also allows its free movements.

Structure of human heart can be studied under two heads for easy understanding, i.e., external and internal structure. '

External Structure

Externally, the human heart is composed of four chambers, i.e., two relatively small upper chambers called auricles (sing, atria) and two larger lower chambers called ventricles.

The right atrium is slightly larger than the left atrium. Both these atria are meant to receive blood from different body parts.

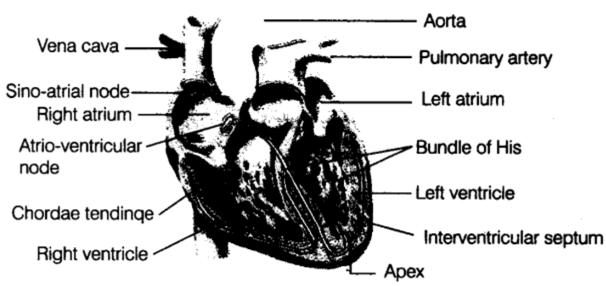


Fig. 18.2 Section of a human heart

Internal Structure

Internally, the chambers of heart, i.e., two auricles (atria) and ventricles are separated by different septa and valves.
Auricles (Atria)

These are the upper two thin-walled and smaller chambers. These serve to receive the blood, therefore are called receiving chambers (right atrium and left atrium). Both the right and the left atria are separated by a thin, muscular wall known as interatrial septum.

(AS) Right Atrium This right chamber deals with only impure (deoxygenated) blood. It receives impure blood from various parts the body, through two major veins, i.e., superior and inferior vena cana. It also receives blood from the walls of the heart itself (through a coronary sinus).

(b) Left Atrium This chamber is meant to deal with only pure (oxygenated) blood. It receives blood (pure) from lungs through two pulmonary veins (i.e., one from the each lung).

Ventricles
These are lower two chambers of the heart, that pumps the blood away from the heart. Thus, function as pumping chambers. Both the right and the left ventricles are separated by the interventricular septum. The atrium and the ventricle of the same side are also separated by another septum, a thick fibrous tissue called atrio-ventricular septum (i.e., AY septum).

As ventricles major function is pumping of blood, due to this, they need thick muscular walls.
(a) Right Ventricle It receives impure blood from right atrium and pumps to pulmonary artery, which further takes this blood to lungs for purification.
(b) Left Ventricle It receives pure (oxygenated) blood from left atrium and pumps its pure blood to aorta (largest artery in the pathway), which inturn takes this blood to whole body and organs.

Cardiac Valves
Apart from septum, heart is also separated by the various valves. These valves acts as a door like structure in the heart that serves to maintain the unidirectional

flow of blood.

Different valves present in the heart are given below

(i) Tricuspid Valve It is formed by three muscular flaps or cusps to guard the opening between the right atrium and the right ventricle.
(ii) Bicuspid Valve (Mitral valve) It is the type of valve that guards the opening between the left atrium and the left ventricle.
(iii) Semilunar Valve The opening of the right and the left ventricles into the pulmonary artery and the aorta respectively are provided with the semilunar valves.

Functions of Cardiac Valves

The valves in the heart allows the flow of blood only in one direction, i.e., from the atria to ventricles and from the ventricles to the pulmonary artery or aorta but also prevent any backward flow of blood.

Conducting System of Heart

The entire heart is made up of cardiac muscles. The ventricular walls are thicker than that of the atrial walls. The rhythm of heart is maintained by a highly specialised cardiac musculature called the nodal tissue distributed in the heart.

1. The Sino-Atrial Node or SA Node (SAN)

SA node is a small flattened patch of tissue present in the right upper corner of the right atrium. The impulse generated by this node spreads in all directions of the heart (i.e., go to both auricles and causes their relaxation and contraction).

2. The Atrio-Ventricular Node or AV Node (AVN)

The signals becomes weak when they reach ventricles because ventricles are far away from SA node thus, to strengthen these signals, another mass of tissue is seen in the lower left corner of the right atrium close to the atrio-ventricular septum {i.e., at the junction of ventricles and atrium) known as AV node. This is also known as pacesetter.

AV node is used to receive the impulses from the SA node through an internodal pathway.

3. Bundle of His

A bundle of nodal fibres, i.e., atrioventricular bundle (AV bundle) continues from the AV node, which passes through the atrio-ventricular septa to emerge y on the

top of the inter-ventricular septum immediately dividing into a right and left buqdle.
This bundle give rise to a network of minute fibres (which are myocardial in origin) throughout the ventricular musculature of the respective side known as Purkinje fibres. These fibres along with the right and left bundles are called bundle of his.
It generates impulses for beating. Normally it does not generates impulse,but strengthen them.
The Purkinje fibres supply impulses to all portions of ventricular walls.

Differences between SA Node and AV Node

SA Node	AV Node
It is located at the upper lateral wall of right auricle.	It is situated at the base of right auricle, near auriculo vetricular junction.
It generates impulses for beating.	Normally it does not generates impulse, but strengthen them.
SA node is also called pacemaker.	AV node is also called pacesetter.
It supplies signals directly to auricles.	It supplies signals to ventricles.
It is not associated with bundle of His and Purkinje fibres.	It is associated with bundle of His and Purkinje fibres.

Working of Nodal Tissue

The nodal musculature possess the ability of generating action potentials without any external stimuli, i.e., it is autoexcitable. However, the nodal system generates different number of action potential at different parts in a minute. The SAN can generate the maximum number of action potentials, i.e., 70-75 min .
It is also responsible for the initiation and maintenance of the rhythmic contractile activity of the heart. Therefore, the SAN (i.e., SA node) is also called pacemaker.
Our heart normally beats 70-75 times in a minute [i.e., average 72 beats/min).

Blood Vessels

As man has a closed circulatory system the blood strictly flows in a fixed route through arteries and veins maintain a continuous flow throughout the body inside the closed tubes or blood vessels.
These tubes or vessels are of mainly two types
Arteries
These blood vessels carry blood from the heart to different body parts. All arteries carry pure or oxygenated blood, with the exception of pulmonary artery

that carries the impure or deoxygenated blood {i.e., from heart to the lungs for purification). As the walls of arteries are thick and non-collapsible, the pressure inside them is very high.
Arteries are much deeply placed in the body.

Features of Arteries
(a) Valves are absent in arteries.
(b) Arteries are divided into five branches, known as arterioles, which are further divided to form finer branches, called capillaries.

Veins
These are another type of blood vessels that bring blood from different body parts to the heart, i.e., carry blood towards the heart. All veins are meant to carry impure blood except the pulmonary vein that carries pure blood, i.e., from lung to the heart. Veins are provided with valves to prevent backward flow of blood.

Differences between Arteries and Veins

Arteries	Veins
Arteries carry blood from the heart to the different parts of the body.	Veins bring back blood from different parts of the body to the heart.
The wall of arteries are thick and muscular.	The wall of the veins are thin and non-muscular.
They are usually deep seated.	They are situated superficially.
The flow of the blood is fast as the blood in arteries is under great pressure.	The flow of blood in veins is not so fast because the blood in veins is under low pressure.
Except the pulmonary arteries, all the arteries carry oxygenated blood.	Except pulmonary veins all the vein carry deoxygenated blood.
Arteries have no valves.	Veins have valves to prevent backflow of the blood.

Cardiac Cycle
The heart pumps the blood to all parts of the body. The changes that takes place in heart during one heart beat, together constitutes cardiac cycle.

The heart beats at an average rate of about 72 times/min. Thus, the total duration of a cardiac cycle is 0.8 s. During a heart beat, the contraction and relaxation of atria and ventricles takes place.

The phase of contraction is known as systole, while the relaxation phase is called the diastole. Thus, a single heart beat consists of a systole and diastole of both the atria and the ventricles.

To begin with the cardiac cycle, all four chambers of heart are in a relaxed state, i.e., they are in joint diastole, during which, the blood flows from the superior and the inferior venae cavae into the atria and from there to the respective ventricles through auriculo-ventricular valves.

The complete cardiac cycle is comprised of following events that takes place in a sequential manner

Atrial Systole
A wave of contraction occurs from anterior to posterior side stimulated by the SA node. The blood flows from the pulmonary veins and vena cava into the left and right ventricles respectively as the tricuspid and bicuspid valves are open.

During this time the blood does not return to the great veins (as blood is already present in them). The semilunar valves are closed. The atrial systole increases the flow of blood into the ventricles by about 30% (as 70% filling of ventricles occurs passively during relaxation of ventricles, before the atrial contraction).

At the end of the atrial systole, there start relaxation of the atria (atrial diastole) and contraction of the ventricles (ventricular systole) simultaneously.

The atrial systole occurs for 0.1s, while the atrial diastole on the other hand is of about 0.7s.

Ventricular Systole
This step involves the simultaneous relaxation of atria (atrial diastole) and contraction of ventricles (ventricular systole).

As the contraction of the ventricles begins, the pressure of blood rises in them almost immediately (above the pressure in the atria). This rapidly closes the atrio-ventricular valves, in order to prevent the back flow of blood from ventricles to atria.

The conduction of action potential to the ventricular side occurs by the AV node and AV bundle from where the bundle of His transmits it through the entire ventricular musculature.

The contraction of ventricles thereby, increases the ventricular pressure causing the closure of the tricuspid and bicuspid valves due to attempted backflow of blood into the atria.

Finally, due to this, the increase in the pressure occurs in the great arteries (i.e., pulmonary and aortic arches), so, semilunar valves guarding the pulmonary artery (right side) and the aorta (left side) are forced open and blood enter through great arteries into ventricles.

When ventricles relax (ventricular diastole), the ventricular pressure falls which causes the closure of semilunar valves preventing the backflow of blood into the ventricles.

A further decline in the ventricular pressure, pushes open the tricuspid and bicuspid valves by the pressure in the atria exerted by the blood, which was being emptied into them by the veins. This allows the blood to move freely to the ventricles once again.

The ventricles and atria are now again in a relaxed state (joint diastole) as earlier.

Soon, the SAN generates a new action potential and the events described above sequencially repeated to continue the process (next cardiac cycle).

Heart Rate and Cardiac Output

We have just studied that, our heart beats for about 72 times per minute (on an average). This concludes that in a single minute, many cardiac cycles are performed. Thus, deducing that duration of a each cardiac cycle is 0.8 s.
During each cardiac cycle (i.e. in one beat) each ventricle pumps out about 70 mL of blood known as stroke volume.
The volume of blood pumped out by each ventricle in one minute is called cardiac output.

We know that, in one minute heart beats for 72 times. Thus, cardiac output will be 5000 mL or approx. 5L in a normal individual.

Thus, Cardiac output = Stroke volume x Numbers of beats /min.

It is to be noted that the body has the ability to alter stroke volume as well as the heart rate and thereby, the cardiac output.

For example Athlete has much higher cardiac output than the normal man.

Heart Sounds
During each cardiac cycle, two prominent sounds are produced which can be easily heard by a stethoscope (an instrument used for the amplification of sound). This allows to hear sounds and pulse of an individual. The basic reason for the production of these sounds is the closure of various valves.

The sounds cardiac produced during each heart beat are as follows
i. Lub It is the first sound, being produced when inter auriculoventricular valves (tricuspid and bicuspid valve) are closed. This.marks the end of the atrial systole and beginning of ventricular systole.
ii. Dub It is the $ pond sound being produced when semilunar valves (of aorta and pulmonary artery) get closed. This marks the end of ventricular systole.

Electrocardiograph EGG:
It is a graphical representation of the electrical activity of the heart during a single cardiac cycle. The electrocardiogram is obtained by a machine known as electrocardiograph. The study or the process of recording of electrocardiogram is called electrocardiography.

Einthoven (1903) is known as 'father of electrocardiography'. The impulse generated by the SA node causes contraction and relaxation of heart chambers.To obtain an ECG, a patient is connected to the machine with three electrical leads (i.e„ one to each wrist and one to the left ankle), monitoring the activity of heart continuously and heart's functioning is evaluated by attaching multiple leads to the chest region.

Reading an ECG

An ECG consists of five peak, identified with the letter P to T that corresponds to a specific electrical conductivity of the heart.

These corresponds to a specific electrical activity of the heart as follows

i. P Wave It is the first and the foremost wave of low amplitude. It represents the electrical excitation or depolarisation of the atria which, leads to contraction of both the atria.

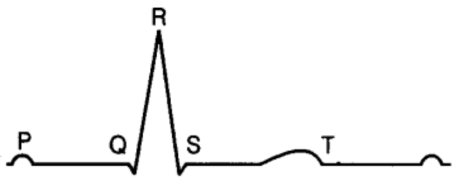


Fig. 18.3 Diagrammatic representation of a standard ECG

ii. QRS Wave or Complex The Q, R and S wave together forms the QRS complex. This represents the depolarisation of the ventricles, which initiates the ventricular contraction.

It marks the spread of impulse from AV node to ventricles, through bundle of His and Purkinje fibres. The contraction starts shortly after Q and marks the beginning of the systole. R is the most conspicious wave out of all, having highest amplitude.

iii. T Wave It is a broad and smoothly rounded deflection, which represents the return of the ventricles from excited to normal state (repolarisation). The end of T wave marks the end of systole. It has been observed that, by counting the number of QRS complexes, that occur in a given time period, one can easily determine the rate of heart beat of an individual.

However, the deviation in the EGG of any person from the normal shape ECG, indicates a possible abnormality or a diseases. .

Significance of ECG

ECG is proved to be of great clinical significance due to following reasons

(a) It gives accurate information about the normal functioning of atria and ventricles.

(b) Indicates the functioning of valves.

(c) ,$lso helps in indicating any damage to local tissues of the heart in detection of over growth of cardiac/heart chambers.

Tachycardia is a term applied to a rapid heart or pulse rate (over 100/min). Bradycardia is the term indicating a slow heart or pulse rate (under 50/min).

MCQ Questions for Class 5 Biology Chapter 18 Body Fluids and Circulation with Answers

Question 1.
In developing embryo RBCs are formed in
(a) Lymph node
(b) Bone marrow
(c) Liver
(d) Spleen

Answer
Answer: (c) Liver

Question 2.
In humans, blood passes from the post caval to the diastolic right atrium of heart due to:
(a) Pressure difference between the post caval and atrium
(b) Pushing open of the venous valves
(c) Suction pull
(d) Stimulation of the sino auricular node

Answer
Answer: (a) Pressure difference between the post caval and atrium

Question 3.
When body tissues are injured resulting in the loss of blood, the process of blood clot begins and the blood platelets release
(a) Fibrinogen
(b) Thrombin
(c) Prothrombin
(d) Thromboplastin

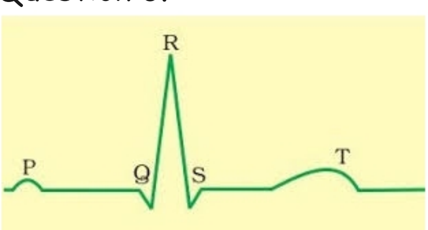
Answer
Answer: (d) Thromboplastin

Question 4.
An adult human has systolic and diastolic pressures as:
(a) 80 mm Hg and 120 mm Hg
(b) 120 mm Hg and 80 mm Hg
(c) 50 mm Hg and 80 mm Hg
(d) 80 mm Hg and 80 mm Hg

Answer
Answer: (b) 120 mm Hg and 80 mm Hg

Question 5.
Duration of cardiac cycle is
(a) 0.7 sec
(b) 0.9 sec
(c) 0.8 sec
(d) 0.11 sec

Answer
Answer: (c) 0.8 sec
Explanation:
Duration of cardiac cycle is 0.8 seconds.

Question 6.


In the above picture Q represents
(a) exitation of the atria
(b) depolarisation of ventricles
(c) begining of systole
(d) repolarisation

Answer
Answer: (c) begining of systole
Explanation:

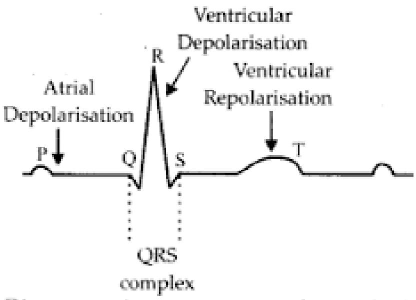


Fig.: Diagrammatic representation of a standard ECG.

Question 7.
Oxygenated blood occurs in
(a) Pulmonary artery
(b) Right atrium
(c) Right ventricle
(d) Pulmonary vein

Answer
Answer: (d) Pulmonary vein

Question 8.
The cells lining the blood vessels belong to the category of
(a) Columnar epithelium
(b) Connective tissue
(c) Smooth muscle tissue
(d) Squamous epithelium

Answer
Answer: (d) Squamous epithelium

Question 9.
Heart failure occurs due to
(a) heart stops beating
(b) damage of heart muscles
(c) congestion of lungs
(d) all of the above

Answer
Answer: (c) congestion of lungs
Explanation:
Heart failure occurs when heart stops pumping blood effectively enough to meet the body needs.
It occurs mainly due to congestion of lungs.

Question 10.
Artificial pace maker is transplanted in
(a) Inter auricular septum
(b) Below the collar bone
(c) Inter ventricular septum
(d) Right auricle

Answer
Answer: (b) Below the collar bone

Question 11.
Which of the following statement/statements can be related to erythroblastosis foetalis?
(a) Severe anemia and jaundice to the baby.
(b) Can be avoided by giving anti-Rh antibodies to mother immediately after delivery of the first child.
(c) Rh-antibodies from the Rh -ve mother destroys foetal RBCs.
(d) All of the above

Answer
Answer: (d) All of the above
Explanation:
Erythroblastosis foetalis occurs if Rh-antibodies from the Rh -ve mother destroys foetal RBCs of Rh +ve foetus.

Question 12.
Among the following stem cells, which are found in the umbilical cord?
(a) Cord blood stem cells
(b) Adult stem cells

(c) Embryonic stem cells
(d) All of the above

Answer
Answer: (a) Cord blood stem cells

Question 13.
If vagus nerve is cut the heart beat
(a) increases
(b) decreases
(c) will not be affected
(d) will stop immediately

Answer
Answer: (a) increases

Question 14.
If due to some injury the chordae tendinae of the tricuspid valve of the human heart is partially non-functional, what will be the immediate effect?
(a) The flow of blood into the pulmonary artery will be reduced
(b) The flow of blood into the aorta will be slowed down
(c) The pacemaker will stop working
(d) The blood will tend to flow back into the left atrium

Answer
Answer: (a) The flow of blood into the pulmonary artery will be reduced

Question 15.
Heparin is
(a) Anti-allergic
(b) Blood diluter
(c) Anticoagulant
(d) Antiseptic

Answer
Answer: (c) Anticoagulant

Question 16.
An adult human has systolic and diastolic pressures as:
(a) 80 mm Hg and 120 mm Hg
(b) 120 mm Hg and 80 mm Hg
(c) 50 mm Hg and 80 mm Hg
(d) 80 mm Hg and 80 mm Hg

Answer
Answer: (b) 120 mm Hg and 80 mm Hg

Question 17.
Cardiac arrest is the state when
(a) heart stops beating
(b) inadequate blood supply to the heart
(c) heart not pumping enough to meet the body needs
(d) blood pressure increases

Answer
Answer: (a) heart stops beating
Explanation:
Cardiac arrest occurs when the heart stops beating.

Question 18.
What is the normal blood pressure of human beings?
(a) 110/70
(b) 120/70
(c) 120/80
(d) 110/80

Answer
Answer: (c) 120/80
Explanation:
120/80 is the normal measurement to blood pressure.
120 mm Hg is the systolic or pumping pressure.
80 mm Hg is the diastolic or resting pressure.

Question 19.
Arteries are best defined as the vessels which
(a) Carry blood from one visceral organ to another visceral organ
(b) Supply oxygenated blood to the different organs
(c) Carry blood away from the heart to different organs
(d) Break up into capillaries which reunite to form a vein

Answer
Answer: (c) Carry blood away from the heart to different organs

Question 20.
Christmas disease is also known as
(a) Haemophilia B
(b) AIDS
(c) Haemophilia A
(d) Haemolytic jaundice

Answer
Answer: (a) Haemophilia B

Solutions for Class 11 Biology Chapter 18 Body Fluids and Circulation:

Section Name	Topic Name
18	Body Fluids and Circulation
18.1	Blood
18.2	Lymph (Tissue Fluid)
18.3	Circulatory Pathways
18.4	Double Circulation
18.5	Regulation of Cardiac Activity
18.6	Disorders of Circulatory System
18.7	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1. Name the components of the formed elements in the blood and mention one major function of each of them.

Solution: Blood corpuscles are the formed ele-ments in the blood, they constitute 45% of the blood. Formed elements are – (erythrocytes, RBCs or red blood corpuscles), (leucocytes, WBCs or white blood corpuscles) and throm¬bocytes or blood platelets. The major function of RBCs is to transport oxygen from lungs to body tissues and COz from body tissues to the lungs. White blood cells provide immunity to the body. Blood platelets play important role in blood clotting.

2. What is the importance of plasma proteins?
Solution: Plasma proteins constitute about 7 to 8% of plasma. These mainly include albumin, globulin, prothrombin and fibrinogen. Prothrombin and fibrinogen are needed for blood clotting. Albumins and globulins retain water in blood plasma and helps in maintaining osmotic balance. Certain globulins

3. Match Column I with Column II.

Column I	Column II
(a) Eosinophils	(i) Coagulation
(b) RBC	(ii) Universal recipient
(c) AB Group	(iii) Resist infections
(d) Platelets	(iv) Contraction of heart
(e) Systol	(v) Gas transport

Solutlion.(a) – (iii); (b) – (v); (c) – (ii); (d) – (i); (e) – (iv).

4. Why do we consider blood as a connective tissue?
Solution: A connective tissue connects different tissues or organs of the body. It consists of living cells and extracellular matrix. Blood is vascular connective tissue, it is a mobile tissue consisting of fluid matrix and free cells. Blood transports materials from one place to the other and thereby establishes connectivity between different body parts.

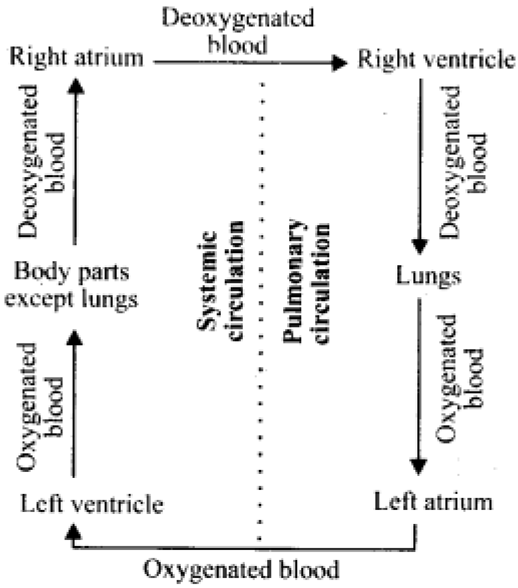
5. What is the difference between lymph and blood?

Solution: The differences between blood and lymph are given below:

	Blood	Lymph
(i)	It consists of plasma, erythrocytes, leucocytes and platelets.	It consists of plasma and leucocytes (lymphocytes most abundant).
(ii)	It is red in colour due to the presence of haemoglobin in erythrocytes.	It is colourless as haemoglobin is absent.
(iii)	Its plasma has more proteins, calcium and phosphorus.	Its plasma has fewer proteins and less calcium and phosphorus.
(iv)	It carries materials towards and away from the tissue, therefore, it acts as a "vehicle".	It transfers materials from the blood to the body cells and *vice-versa*, therefore, it acts as a "middle man".

6. What is meant by double circulation? What is its significance?

Solution: The type of blood circulation in which oxygenated blood and deoxygenated blood do not get mixed is termed double circulation. It includes systemic circulation and pulmonary circulation. The circulatory pathway of double circulation is given in the following flow chart.



Flow chart : Double blood circulation

Flow chart: Double blood circulation Double circulation or separation of systemic and pulmonary circulations provides a higher metabolic rate to the body and also allows the two circulations to have different blood pressures according to the need of the organs they supply.

7. Write the differences between:
(a) Blood and lymph
(b) Open and closed system of circulation
(c) Systole and diastole
(d) P-wave and T-wave

Solution: (a) Refer answer 5.

(b) The differences between open and closed circulatory system are given below:

	Open circulatory system	Closed circulatory system
(i)	Blood flows through open tissue spaces, the sinuses.	Blood flows in closed tubes, the blood vessels, with definite walls.
(ii)	Blood is in direct contact with the tissue cells.	Blood does not come in direct contact with the tissue cells.

(iii)	Exchange of materials occurs directly between blood and tissue cells.	Exchange of materials between tissue cells and blood occurs *via* tissue fluid.
(iv)	Blood flow is very slow.	Blood flow is quite rapid.
(v)	Respiratory pigment, if present, is dissolved in the plasma, no red corpuscles are present.	Respiratory pigment is present, and may be dissolved in the plasma but is usually held in red blood corpuscles.
(vi)	Occurs in arthropods and most molluscs.	Occurs in annelids and vertebrates.

(c) Systole is contraction of heart chambers in order to pump out blood while diastole is relaxation of heart chambers to receive blood. The contraction of a chamber or systole decreases its volume and forces the blood out of it, whereas its relaxation or diastole brings it back to its original size to receive more blood.
(d) P wave is a small upward wave of elec-trocardiograph that indicates the atrial depolarisation (contraction of atria). It is caused by the activation of SA node. T-wave is a dome shaped wave of electro-cardiograph which represents ventricular repolarisation (ventricular relaxation).

8. Describe the evolutionary change in the pattern of heart among the vertebrates.

Solution: Vertebrates have a single heart. It is a hollow, muscular organ composed of cardiac muscle fibres. Two types of chambers in heart are atria and ventricles. The heart of lower vertebrates have additional chambers, namely sinus venosus and conus arteriosus or bulbus arteriosus or truncus arteriosus. During the course of development, in higher vertebrates, the persistent portions viz, auricles and ventricles are retained. However, these get complicated by incorporating several valves inside them and becoming compartmentali sed.
In fishes, heart is two chambered (1 auricle and 1 ventricle). Both the accessory chambers, sinus venosus and conus arteriosus are present. The heart pumps out deoxygenated blood which is oxygenated by the gills and sent to the body parts

from where deoxygenated blood is carried to the heart. It is called single circulation and heart is called venous heart. Lung fish, amphibians and reptiles have three chambered heart, (2 auricles and 1 ventricle). The left atrium gets oxygenated blood from the gills/lungs/skin/buccopharyngeal cavity and the right atrium receives the deoxygenated blood from other body parts. But both oxygenated and deoxygenated blood get mixed up in single ventricle which pumps out mixed blood. This is called incomplete double circulation.
Crocodiles, birds and mammals have a complete four chambered heart (right and left auricles; right and left ventricles). Oxygenated and deoxygenated blood never get mixed. Right parts of the heart receive deoxygenated blood from all other body parts and send it to lungs for oxygenation whereas left parts of heart receive oxygenated blood from lungs and send it to other body parts. This mode of circulation is termed as complete double circulation which includes systemic and pulmonary circulation. There are no accessory chambers in heart of birds and mammals.

9. Why do we call our heart myogenic?

Solution: The heart of molluscs and vertebrates including humans is myogenic. It means heart beat is initiated in heart itself by a patch of modified heart muscle called sino-atrial node or pacemaker which lies in the wall of the right atrium near the opening of the superior vena cava.

10. Sino-atrial node is called the pacemaker of our heart. Why?

Solution: Sino-atrial node (SAN) is a mass of neuromuscular tissue which lies in the wall of right atrium. It is responsible for initiating and maintaining the rhythmic contractile activity of the heart. Therefore, it is called the pacemaker.

11. What is the significance of atrio-ventricular node and atrio-ventricular bundle in the functioning of heart?

Solution: atrio-ventricular node (AVN) is a mass of neuromuscular tissue, which is situated in wall of. right atrium, near the base of inter-atrial septum. AV node is the pacesetter of the heart,- as it transmits the impulses initiated by SA node to all parts of ventricles. Atrio-ventricular bundle (A-V bundle) or bundle of His is a mass of specialised fibres which originates from the AVN. Within the myocardium of the ventricles the branches of bundle of His divide into a network of fine fibres called Purkinje fibres. The bundle of His and the Purkinje fibres convey impulse of contraction from the AVN to the myocardium of the ventricles.

12. Define a cardiac cycle and the cardiac output.

Solution: The sequential events in the heart which are repeated cyclically is called cardiac cycle and it consists of systole (contraction) and diastole (relaxation) of both the atria and ventricles. The duration of a cardiac cycle is 0.8 seconds. Periods of cardiac cycle are atrial systole (0.1 second), ventricular systole (0.3 second) and complete cardiac diastole (0.4 second).

The amount of blood pumped by heart per minute is called cardiac output. It is calculated by multiplying stroke volume (volume of blood pumped by each ventricle per minute) with heart rate (number of beats per minute). The heart of normal person beats 72 times per minute and pumps out about 70 mL of blood per beat. Therefore, cardiac output averages 5000 mL or 5 litres.

13. Explain heart sounds.

Solution: The beating of heart produces characteristic sounds which can be heard by using stethoscope. In a normal person, two sounds are produced per heart beat. The first heart sound Tubb' is low pitched, not very loud and of long duration. It is caused partly by the closure of the bicuspid and tricuspid valves and partly by the contraction of muscles in the ventricles.

The second heart sound 'dubb' is high pitched, louder, sharper and shorter in duration. It is caused by the closure of the semilunar valves and marks the end of ventricular systole.

14. Draw a standard ECG and explain the different segments in it.

Solution: ECG is graphic record of the electric current produced by the excitation of the cardiac muscles. The instrument used to record the changes is an electrocardiograph. A normal electrogram (ECG) is composed of a P wave, a QRS wave (complex) and a T wave. The P Wave is a small upward wave that represents electrical excitation or the atrial depolarisation which leads to contraction of both the atria (atrial contraction). It is caused by the activation of SA node. The impulses of contraction start from the SAnode and spread throughout the artia.

The QRS Wave (complex) represents ventricular depolarisation (ventricular contraction). It is caused by the impulses of the contraction from AV node through the bundle of His and Purkinje fibres and the contraction of the ventricular muscles. Thus this wave is due to the spread of electrical impulse through the ventricles.

The T Wave represents ventricular repolarisation (ventricular relaxation). The potential generated by the recovery of the ventricle from the depolarisation state is called the repolarisation wave. The end of the T-wave marks the end of systole.

ECG gives accurate information about the heart. Therefore, ECG is of great diagnostic value in cardiac diseases.

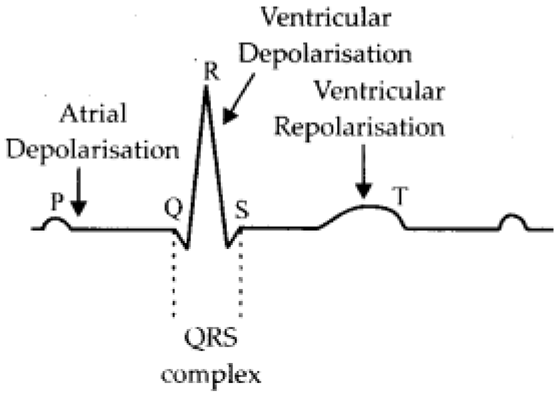


Fig.: Diagrammatic representation of a standard ECG.

Excretory Products and their Elimination Class 5 Notes Biology

- Topic 1 Excretion: Major Products, Human System and Uropoiesis
- Microscopic Structure
- Types of Nephrons
- Topic 2 Excretion : Various Controlling Mechanisms and Disorders
- Role of Other Organs in Excretion

Excretion is the removal of nitrogenous waste products and other metabolites from the animal body which is normally associated with the process of maintenance of osmibtic concentrations, i.e., osmoregulation within the body.
Both excretion and osmoregulation are important for the maintenance of homeostasis, i.e., for keeping the internal environment of the body constant that is necessary for normal life processes.
Ammonia, urea and uric acid are the major forms of nitrogenous wastes excreted by animals. These substances get accumulated in the animal body either by metabolic activities or by other means like excess ingestion.

Topic 1 Excretion: Major Products, Human System and Uropoiesis

Types of Nitrogenous Excretion

Depending upon the nature of excretory product, animals exhibit different processes of nitrogenous excretion.

These are described as follows

(i) Ammonotelism Ammonia is the most toxic form of nitrogenous waste, it requires large amount of water for its elimination. The organism that excrete ammonia are called ammonotelic and this , process to eliminate ammonia is known as ammonotelism.
Examples of ammonotelic animals are Many bony fishes, aquatic amphibians and aquatic insects. Ammonia, as it is readily soluble, is generally excreted by diffusion across body surfaces or through gill surfaces (in fish) as ammonium ions.
Kidneys does not play any significant role in its removal.
(ii) Ureotelism The process of excreting urea is called ureotelism. Animals, which does not live in high abundance of 'water convert ammonia produced in the body

into urea (in the liver) and release into the blood, which is filtered and excreted out by the kidneys.
Examples of ureotelic animals are Mammals, many terrestrial amphibians and marine fishes.
(iii) Uricotelism The process of excreting uric acid is called uricotelism. Uric acid, being the least toxic nitrogenous waste can be removed with a minimum loss of water from the animal body.
Thus, it is excreted in the form of pellet or paste (i.e., semi-solid form). Normally, the animals which live in desert exhibit uricotelism.
Examples of uricotelic animals are Reptiles, birds, land snails and insects.
Note:
Some animals perform dual excretion, i.e., two modes of excretion. For example, Earthworms excrete ammonia when sufficient water is available, while it excretes urea in drier surroundings.
Other examples are lung fishes, Xenopus, crocodiles, etc.
Excretory Organs
Different animal groups have a variety of excretory structures (organs) to perform the process of excretion. In most of the invertebrates, these structures are simple tubular form, whereas, vertebrates have complex tubular organs called kidneys.
Some of these structures are mentioned below in the given table
Excretory Organs and Main Nitrogenous Wastes of Different Animal Croups

Animal Groups	Excretory Organs	Main Nitrogenous Waste
Protozoans (*Amoeba*), Poriferans (*Sycon*), Coelenterates (Cnidaria) (*Hydra*)	Plasma membrane, pellicle and general body surface	Ammonia
Ctenophora	Anal pores	Ammonia
Platyhelminthes (flatworms) *e.g., Planaria, Fasciola, Taenia*	Protonephridia with flame cells	Ammonia
Rotifers	Flame cells	Ammonia
Nemathelminthes (Aschelminthes) *e.g.*, Roundworms, *Ascaris*	Renette cells	Ammonia and urea
Annelids	Metanephridia (in *Nereis* and leech), Metanephridia and chloragogen cells (in earthworm)	Ammonia and urea
Arthropoda	Malpighian tubules (in cockroaches), coxal gland, green glands or antennary glands (in crustaceans)	Uric acid and ammonia
Mollusca	Renal gland or organ of Bojanus (in *Pila* and *Unio*) and Keber's organ (in *Unio*)	Ammonia in aquatic and uric acid in larva forms
Echinodermata	Tube feet (podia) and dermal branchiae (thin walls of gills)	Ammonia
Chordata	Protonephridia (in lancelets), neural gland (in *Herdmania*), pharyngeal nephridia and Hatschek's nephridium in cephalochordates (*Amphioxus*). One pair of kidneys in vertebrates	Ammonia, urea and uric acid

Human Excretory System

Human excretory system consists of a pair of kidneys, a pair of ureters, urinary bladder and urethra, these are described below in detail

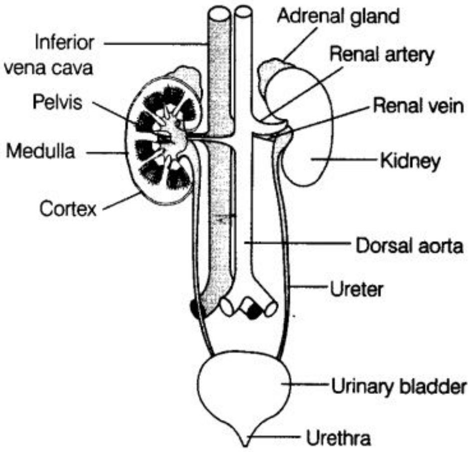


Fig. 19.1 Human excretory system

1. Kidneys

These are reddish brown, bean-shaped structures situated between the levels of last thoracic and third lumbar vertebra close to the dorsal inner wall of the abdominal cavity. –

Kidneys are mesodermal in origin as they developed from mesodermal nephrostomes or mesomeres (ciliated structures, functional in embryonic conditions).

Position of Kidneys

The kidneys are located below the diaphragm on the left and right sides. The right kidney is lower and smaller than the left kidney because the liver takes up much space of the right side.

Note:

Each kidney of an adult human measures. 10-12 cm in length, 5-7 cm in width, 2-3 cm in thickness with an average weight of 120-170 gm (i.e., 150 gm in males and about 135 gm in females).

Structure of Kidney

Structure of kidney can be studied well under two heads, i.e., external as well as internal structure.

These are described below as

The outer surface of each kidney is convex and inner surface is concave, where it has a notch called hilum, through, which the supply of blood occurs, i.e., renal artery and renal vein, pass in and out of the kidneys along with the ureter and the nerve supply of kidney.

If we look from outside to inside, three layers cover the kidneys, i.e., renal fascia (outermost), the adipose layer and then renal capsule (innermost layer). These

coverings protect the kidneys from external shocks and injuries.
The LS of a mammalian kidney seems to have of an outer cortex and inner medulla.

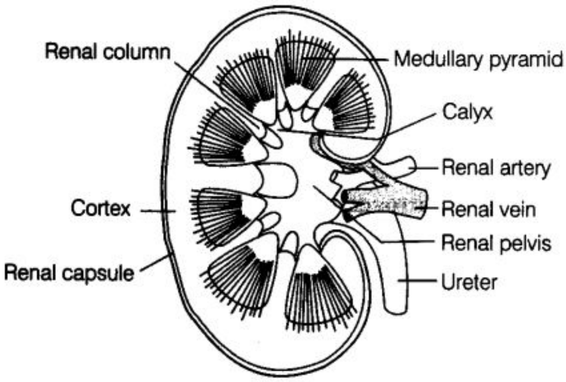


Fig. 19.2 LS of kidney

Inside the kidney, the ureter is expanded as a funnel-shaped cavity called pelvis. The free end of pelvis has number of cup-like cavities called calyces (sing, calyx) major and minor.
Medulla projects into the calyces as conical processes, called renal pyramids or medullary pyramids. The tip of pyramids are called renal papillae. The cortex spreads in between medullary pyramids as renal columns called columns of Bertini.

Microscopic Structure

Each kidney is composed of numerous (nearly one million) complex tubular structure called nephrons, which are the functional units of kidney.

Structure of Nephron Uriniferous Tubule

Each nephron consists of two parts, i.e., the Malpighian body or renal corpuscle and the renal tubule.

i. Malpighian Body or Renal Corpuscle

Glomerulus along with Bowman's capsule is called the Malpighian body or renal corpuscle which filters out large solutes from the blood and delivers small solutes to the renal tubule for modification.

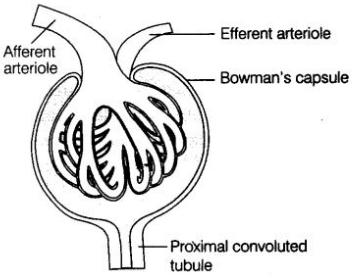


Fig. 19.3 Malpighian body (renal corpuscle)

Glomerulus It is a tuft of capillaries formed by the afferent arteriole (a fine branch of renal artery).
The afferent arteriole is short and wide that supplies blood to the glomerulus,

while, the efferent arteriole is narrow and long carrying blood away from the glomerulus.

Differences between Afferent Arteriole and Efferent Arteriole

Afferent Arteriole	Efferent Arteriole
These are the fine branches of renal artery which enter in each kidney and arise from dorsal aorta.	These are the fine branches of renal vein which leave the kidney and joins with inferior vena cava.
They bring arterial blood to the renal corpuscles.	They carry venous blood away from the renal corpuscles.
Its diameter is more.	Its diameter is comparatively less.
The blood flowing in it is rich in waste products.	The blood flowing in it is poor in waste products.

ii. Bowman's Capsule (Glomerular capsule) It is a double walled cup-like structure that surrounds the glomerulus. The outer parietal wall which is composed of flattened (squamous) cells and the inner visceral wall is composed of a special type of less flattened cells, called podocytes.

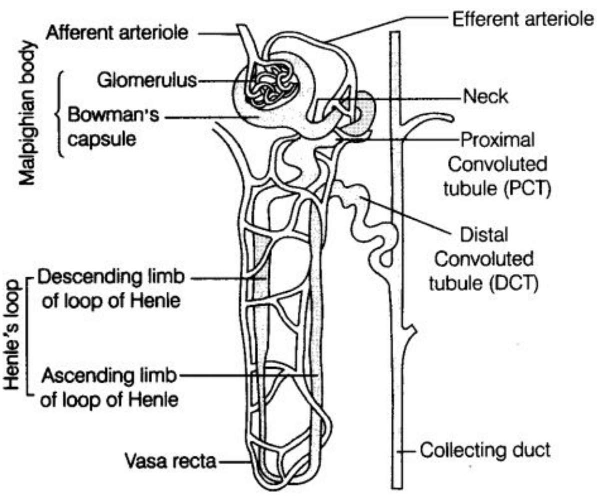


Fig. 19.4 A diagrammatic representation of a nephron

iii. Renal Tubules

Just below the glomerulus, the tubule has a very short neck.

Attached to each Bowman's capsule is a long, thin tubule with three distinct regions.

These regions are described as follows

(a) Proximal Convoluted Tubule (PCT) Behind the neck, it makes few coils and is restricted to the cortical region of the kidney.

(b) Henle's Loop It is quite narrower and U-shaped (or hair pin-shaped) having a descending limb that ends into the medulla and an ascending limb that extends back from the medulla into the cortex.

Differences between Descending Limb and Ascending Limb of Henle's Loop

Descending Limb	Ascending Limb
It is very thin.	It is thick.
Direction of fluid flow is downward.	Direction of fluid flow is upward.
Permeable to water.	Impermeable to water.

Note:

- Peritubular Capillary Network (PTCN), is formed when a minute vessel of peritubular capillaries runs parallel to the loop of Henle forming a U-shaped vasa recta.
- All these capillaries join to form renal venules, which join to form a renal vein that opens into the inferior vena cava.

Types of Nephrons

Based on the location in the kidney, nephrons are of following two types

1. Cortical Nephrons

In majority of nephrons, the loop of Henle is too short and extends only very little into the medulla i.e., lie in the renal cortex. Such two nephrons are called cortical nephrons.

Juxtamedullary Nephrons

In some of the nephrons, the loop of Henle is very long and runs deep into the medulla. These nephrons are called juxtamedullary nephrons.

The cortical nephron forms about 80% of the total nephron count while rest 20% are the juxtamedullary nephron.

Functions of Kidney

Following functions are served by kidney

(i) Regulation of water and electrolyte balance.

(ii) Regulation of arterial pressure.

(iii) Excretion of metabolic waste and foreign chemicals.

(iv) Secretion of hormones like renin.

2. Ureters

The pelvis of each kidney is continued as a ureter and emerges out at hilus. Ureter is a long and muscular tube. Ureters of both sides extend posteriorly and open into the urinary bladder.

3. Urinary Bladder
It is a thin-walled, pear-shaped, white transparent sac present in the pelvic cavity. It temporarily stores the urine.
4. Urethra
It is a membranous tube, which conduct urine to the exterior. The urethral sphincters keep the urethra closed except during voiding of urine.

The formation of urine is the result of the following processes
1. Glomerular Filtration
The first step of urine formation is the filtration of blood, which is carried out by the glomerulus. That's why this step is called glomerular filtration.
Kidneys filter about 1100-1200 mL of blood per minute, which constitute roughly l/5th of the blood pumped out by each ventricle of the heart in a minute.
The glomerular capillary bloodpressure causes filtration of blood through three layers, i.e.,
(i) the endothelium of glomerular blood vessels.
(ii) the epithelium of Bowmans capsule.
(iii) a basement membrane (present between the above mentioned two layers).
The podocytes (epithelial cells of Bowman's capsule) are arranged in such a manner so, as to leave some minute spaces called filtration slits or slit pores.
On account of the high pressure in the glomerular capillaries, the substances are filtered through these pores into the lumen of the Bowman's capsule (but the RBC, WBC and plasma proteins having high molecular weight are unable to pass out).
That's why this process of filtration through glomerular capillaries in the Bowman's capsule is known as ultra filtration and the filtrate is called glomerular filtrate or primary urine.
It is hypotonic to urine that is actually excreted. Basic function of nephron is to clear out the plasma from unwanted substrates and also maintain the osmotic concentration of the blood plasma. Thus, the fluid coming out is known as urine, whose formation occurs inside the kidney.
Glomerular Filtration Rate .The amount of the filtrate formed by the kidneys per minute is called Glomerular Filtration Rate (GFR). In a healthy person it was found approximately 125 mL/min, i.e., 180 L/day.
GFR is regulated by one of the efficient mechanism carried out by Juxtaglomerular Apparatus (JGA).
JGA is a special sensitive region formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact.

This apparatus includes

(i) granular juxtaglomerular cells in the afferent arteriole.

(ii) macula densa cells of DCT.

(iii) agranular lacis cells situated in between the above two.

A fall in GFR can activate the JG cells to release renin, which can stimulate the glomerular blood flow and thereby, the GFR back to normal.

2. Selective Reabsorption

This is the second step in the formation of urine from filtrate. The urine released is 1.5 L as compared to the volume of the filtrate formed per day (180 L). It suggests that as much as 99% of the material in the filtrate is reabsorbed by the renal tubules. Thus, the process is called reabsorption.

Depending upon the types of molecules being reabsorbed, movements into and out of epithelial cells in different segments of nephron occur either by passive transport or active transport.

These are described as follows

(i) Water and urea, are reabsorbed by passive transport (i.e., water is reabsorbed by osmosis and urea by simple diffusion).

(ii) Glucose and amino acids are reabsorbed by active transport.

(iii) The reabsorption of Na+, occurs both by passive and active transport.

3. Tubular Secretion

It is also an important step in urine formation. Certain chemicals in the blood that are not removed by filtration from the glomerular capillaries are removed by this process of tubular secretion. It helps in the maintenance of ionic and acid-base balance of body fluids by removing chemicals like foreign bodies, ions (K^+, H^+, NH^-) and molecules (medicines), etc., that are toxic at elevated levels.

Difference between the Tubular Reabsorption and Tubular Secretion

Tubular Reabsorption	Tubular Secretion
It involves the absorption of water and useful solutes from the glomerular filtrate into the blood.	It refers to the passage of waste materials from blood into the filtrate or nephrons.
It occurs by back diffusion and active transport.	It takes place only by active transport.
It occurs mostly in PCT.	It occurs mostly in DCT.
It does not occcur in animals that lack glomerulus (*e.g.*, Marine fish and desert animals).	It is the only mode of excretion in animals that lack glomerulus.

Functions of the Tubules

When the glomerular filtrate/primary urine passes through renal tubule, water and

different materials of filtrate reabsorb at various places.
These are given below in the following manner

i. Proximal Convoluted Tubule (PCT)

The epithelial cells of the PCT have numerous microvilli (simple cuboidal brush-border epithelium) which increase the surface area available for reabsorption.
The process of reabsorption mostly (65%) takes place within PCT (i.e., nearly all of the essential nutrients, 70-80% of electrolytes and water). PCT also helps in the absorption of HCO^- from the filtrate.
Selective secretion of hydrogen ions, ammonia and potassium ions takes place here to maintain the pH and ionic balance of the body fluids. The filtrate is considered isotonic to blood plasma.

ii. Henle's Loop

Reabsorption in Henle's loop is minimum, besides it, this plays an important role in maintaining the high osmolarity of medullary interstitial fluid. Two portions of Henle's loop, play different role in osmoregulation such as

a. Descending Limb of Loop of Menu?

Water is reabsorbed here due to increasing osmolarity of interstitial fluid but, sodium and other electrolytes are not reabsorbed here. This concentrates the filtrate as it moves down.

b. Ascending Limb of Loop of Menu?

This segment is impermeable to water but permeable to K^+,Cl^- and Na^+ and partially permeable to urea. Thus, in the thick ascending limb of the loop of Henle Na^+, K^+, Mg^{2+} and Cl^- are reabsorbed.
Therefore, as the concentrated filtrate pass upward, it gets diluted due to the passage of electrolytes to the medullary fluid.

iii. Distal Convoluted Tubule (DCT)

Active reabsorption of sodium ions from the filtrate (under the influence of aldosterone) takes place. Water is also reabsorbed here under the influence of Antidiuretic Hormone (ADH).
With associated secretion of potassium (K^+), hydrogen (H^+) ions, NH^-, some Cl^- (chloride) ions and HCO^- are also reabsorbed here. It is necessary to maintain the pH and sodium-potassium balance in blood. This makes the filtrate isotonic to blood plasma.

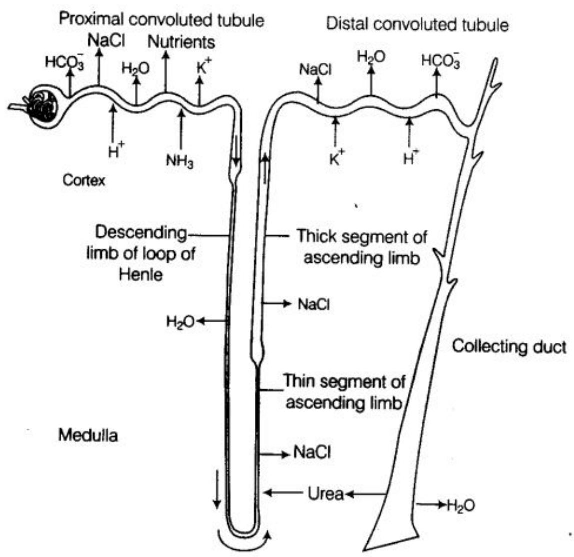


Fig. 19.5 Reabsorption and secretion of major substances at different parts of the nephron (arrows indicate direction of movement of materials)

Collecting Duct

This duct extends from the cortex of the kidney to the inner parts of the medulla and is highly permeable to water. Thus, a considerable amount of water is reabsorbed here under the influence of ADH to produce concentrated filtrate. Sodium is also reabsorbed here under the influence of aldosterone.

CT (Collecting Tubule) allows passage of small amounts of urea into the medullary interstitium to maintain the osmolarity. It also plays an important role in the maintenance of pH and ionic balance of blood by the selective secretion of H^+ and K^+ ions.

Therefore, the filtrate is now called urine. Thus, urine is isotonic to medullary fluid and hypertonic to blood.

Concentrations of important ions and other substances in the blood are controlled by regulating water levels.

Topic 2 Excretion : Various Controlling Mechanisms and Disorders

Counter Current Mechanism

Kidney of higher vertebrates (such as mammals, birds including man) has the ability of absorbing more and more water from tubular filtrate (in the Henle's loop region) to make the urine more concentrated.

This can be achieved by a special mechanism known as counter current mechanism and also known as urine concentration mechanism.

Basic Concept

(i) Henles loop and vasa recta (capillary loop) play an important role in this mechanism. The flow of filtrate in the limbs of Henle's loop is in opposite

directions and thus, forms a counter current. The flow of blood with in the two limbs of vasa recta also occur in the counter current pattern.
(ii) The osmolarity (i.e., number of Osmols of solute per litre) of renal cortical interstitium is the same (300 m Osmol/ L) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolarity from renal cortex to the tips of medullary papillae.
The hyperosmolarity of medullary interstitium near the tips of the papillae is as high as 1200-1450 m Osmol/L.

The Mechanism

The gradient of increasing hyperosmolarity of medullary interstitium is maintained by a counter current mechanism and the proximity between the Henle's loop and vasa recta.
This gradient is mainly caused by NaCl and urea. The transport of these substances is facilitated by the special arrangement of Henle's loop and vasa recta.
There are two aspect of this mechanism
(i) Counter current multiplication (by the Henle's loop).
(ii) Counter current exchange (by the vasa recta).
NaCl is transported by the ascending limb of Henle's loop, which is exchanged with the descending limb of vasa recta.

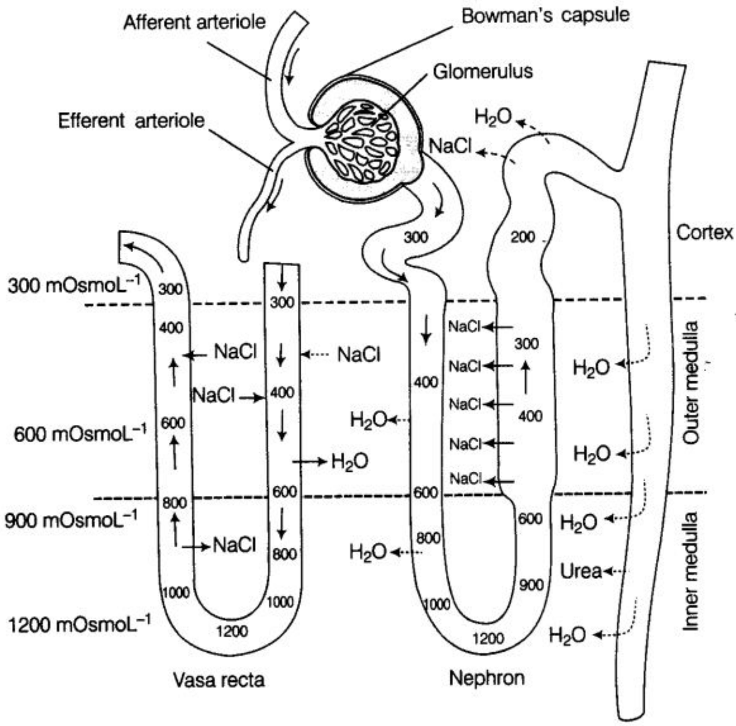


Fig. 19.6 Diagrammatic representation of a nephron and vasa recta showing counter current mechanisms

NaCl is returned to the medullary interstitium by the ascending part of vasa recta.

But, contrarily, the water diffuses into the blood of ascending limb of vasa recta and is carried away into the general.blood circulation.
Permeability to urea is found only in the deeper parts of thin ascending limb of Henle's loops and collecting ducts.
Urea diffuses out of the collecting ducts and enters into the thin ascending limb. A certain amount of urea recycled in this way is trapped in medullary interstitium by the collecting tubule. Thus, collecting tubule also play a minor role in the process (as shown in the figure above).

Note:

The counter current mechanism helps in the maintenance of a concentration gradient in the medullary interstitium.
Presence of such gradient helps in an easy passage of water from the collecting tubule resulting in the formation of concentrated urine (filtrate), i.e., nearly four times concentrated than the initial filtrate formed.

Regulation of Kidney Functions

To maintain homeostasis, the regulation of water and solute contents of the body fluids is performed by the kidneys. The vertebrate kidney is very flexible in its functioning. It excretes larger quantities of dilute urine when water is abundant in the body tissues and small amounts of concentrated urine when there is shortage of water.
Hormones acts as an important signalling molecules in controlling the regulatory processes in the kidneys. The functioning of the kidneys is efficiency monitored and regulated by hormonal feedback mechanisms involving hypothalamus, JGA (Juxtaglomerular Apparatus) and to a certain extent, the heart.
Regulation of the functioning of kidneys can be discussed under the following headings

Regulation by the Hypothalamus

Excessive loss of fluid from the body activates osmoreceptors, which stimulate the hypothalamus to release ADH or vasopressin form the neurohypophysis. ADH facilitates water reabsorption from posterior parts of tubule. An increase in body fluid volume can switch off the osmoreceptors and suppresses the ADH release to complete the feed back. ADH also causes constrictory effects on blood vessels. This causes an increase in blood pressure, which in turn increase the glomerular blood flow and thereby the GFR (Glomerular Filtration Rate).

Regulation by the Juxtaglomerular Apparatus (JGA)

As blood pressure/glomerular blood flow /GFR decreases, the cells of the JGA release the enzyme renin.

Renin converts angiotensinogen in blood to Angiotensin I and Angiotensin II (active form). This mechanism is generally known as the Renin-angiotensin mechanism.

Angiotensin has following effects

(a) Raises blood pressure by constricting blood vessels (being a powerful vasaconstrictor) and thereby, GFR.

(b) Activates the adrenal cortex to release aldosterone.

(c) Aldosterone causes reabsorption of Na^+ and water from the distal parts of the tubule. This also leads
to an increase in blood pressure and GFR.

Regulation by the Heart

Atrial Natriuretic Factor (ANF) produced by the atria of heart can cause vasodilation (dilation of blood vessels) and thereby, decrease the blood pressure. ANF inhibits NaCl reabsorption and concentration of urine.

Micturition

Urine is produced and drained continuously by the nephron into the renal pelvis from here, it is carried down to the ureters and then into the urinary bladder. The bladder serves to store the urine temporarily till a voluntary signal is given by the Central Nervous System (CNS). As urine collects, the muscular walls of the bladder distend to accommodate it. .

The stretch receptors on the walls of the bladder set up reflexes (send signals to the (CNS) by stimulating the sensory nerve ending in the bladder). It causes an urge to pass out urine.

The act of expulsion of urine involves the coordinated contraction (as CNS passes on motor messages) of the smooth muscle of the bladder wall and simultaneous relaxation of the internal and external urethral sphincters. The process of release of urine is called micturition and the neural mechanism causing it is called the micturition reflex.

Note:

Alcohol inhibits the release of ADH and caffeine interferes with ADH action and sodium reabsorption. Thus, both of these artificially dilute the urine and are called diuretics. Urination is a reflex response in babies, but is controlled consciously in older children and adults.

Urine

An adult man normally passes about 1-1.5 L of urine per day.

Composition Urine normally contains, water 95%, salts 2%, urea 2.6%, uric acid 0.3%, traces of creatinine, creatine, ammonia, etc.

Colour Pale yellow, due to pigment urochrome produced by the breakdown of haemoglobin.

pH Ranges from 4.5-8.2, average pH 6.0 (i.e., slightly acidic).
Odour Unpleasant, if allowed to stand imparts strong smell like, ammonia.
Note:
Least concentration of urea is found in renal vein because urea is excreted through urine formed in kidney. On an average, 25-30 g of urea is excreted out per day.
Highest concentration of urine is found in hepatic vein because urea is synthesised in liver.
Analysis of urine helps in clinical diagnosis of many metabolic disorders as well as malfunctioning of the kidney.
For example, presence of glucose (glycosuria) and ketone bodies (ketonuria) in urine are indicative of diabetes mellitus and presence of protein, blood and pus in the urine is called proteinuria, haematuria and pyuria respectively.

Role of Other Organs in Excretion

Other than the kidneys, there are some accessory excretory organs also that help in the elimination of excretory wastes.
These are described as follows
1. Lungs
Carbon dioxide and water are the waste products formed in respiration. Lungs remove the CO_2 and some water as vapour in the expired air. About 18 L of CO_2 per hour and 400 mL of water per day are eliminated by human lungs.
2. Liver
It changes the decomposed haemoglobin of the worn-out red blood corpuscles into bile pigments, i.e., bilirubin and biliverdin. These pigments passes into the alimentary canal with the bile for elimination in the faeces. The liver also excretes cholesterol, steroid hormones, certain vitamins and drugs via bile.
Liver deaminates the excess and unwanted amino acids, producing ammonia, which is quickly combined with CO_2 to form urea in urea cycle or Ornithine cycle, which is further removed by the kidneys.
3. Skin
The sweat and sebaceous glands in the skin can eliminate certain substances through their secretions.
(i) Sweat Glands The secretion of sweat glands (sweat) is an aqueous fluid containing NaCl, lactic acid, small amounts of urea, amino acids and glucose. Control of sweat lost is an example of homeostasis control, for regulating the body temperature (i.e., to facilitate a cooling effect on the body surface).
(ii) Sebaceous Glands Sebum from sebaceous glands eliminates sterols, fatty acids, waxes and hydrocarbons. This secretion is mainly meant for protective oily covering of the skin.

4. Intestine

Epithelial cells of colon excrete excess salts of calcium, magnesium and iron along with faeces.

5. Salivary Glands

Heavy metals and drugs are excreted in the saliva.

Important Metabolic Wastes and Substances Excreted from the Body

Chemical	Source	Organ of Excretion
Ammonia	Deamination (removal of amine group) of amino acids in liver	Kidneys
Bile pigments	Haemoglobin breakdown in liver	Liver (into small intestine)
Carbon dioxide	Breakdown of glucose in cells	Lungs
Inorganic ions	Food and water	Kidneys and salivary glands
Urea	Derived from ammonia	Kidneys and skin
Uric acid	Nucleotide breakdown in liver	Kidneys
Urochrome	Haemoglobin breakdown in liver	Kidneys
Water	Food and water; breakdown of glucose	Kidneys, skin and lungs

Disorders of the Excretory System

Malfunctioning of kidneys can lead to several disorders of the excretory system.

Some of these are as follows

(i) Uremia It is the presence of an excessive amount of urea in the blood. Urea is highly harmful as it poisons the cells at high concentration and may lead to kidney failure.

(ii) Kidney Failure (renal failure) Partial or total inability of kidneys to carry on excretory and salt-water regulatory functions is called renal or kidney failure.

(iii) Renal Calculi It is the formation of stone or insoluble mass of crystallised salts (calcium, magnesium, phosphates and oxalates etc.), formed within the kidney.

(iv) Glomerulonephritis It is the inflammation of glomeruli of kidney.

Artificial kidney (haemodialyser) is a machine that is used to filter the blood (to remove urea and other nitrogenous wastes) of a person, whose kidneys are damaged.

The process is called haemodialysis.

The outline details of apparatus and the process are as follow
(i) It works on the principle of dialysis (i.e., diffusion of small solute molecules through a semipermeable membrane (cellophane).
(ii) Blood of the patient is pumped from one of the arteries into the dialysing unit (haemodialyser) after cooling it to 0°C and mixing with an anticoagulant (heparin).
(iii) Haemodialyser is a cellophane tube suspended in a dialysing fluid (salt-water solution) of the same composition as that of plasma except the nitrogenous wastes (urea).
(iv) Pores of the cellophane tube allow the passage of molecules based on concentration gradient. Nitrogenous wastes like urea, uric acid, creatinine,excess salts and excess H+ ions easily get diffuse from the blood into the surrounding solution. Thus, the blood is cleared of nitrogenous waste products without loosing plasma proteins.
(v) The blood thus, purified, is warmed to body temperature, checked to ensure that it is isotopic to the patients blood. Now, the blood is mixed with an anti-heparin to restore its normal clotting power and then pumped back to the body of patient through a vein, usually the radial vein.
Kidney (Rena!) Transplantation
Grafting a kidney from a compatible donor to restore kidney functions in a recipient suffering from kidney failure is called renal or kidney transplantation. It is an ultimate method in the correction of acute renal failures.
A living donor can be used in a kidney transplant. It may be an identical twin, a sibling or a close relative to minimize the chances of rejection by the immune system of the host. To prevent the rejection of transplanted kidney, special drugs are also used, which suppress the recipients immune system.

MCQ Questions for Class 5 Biology Excretory Products and their Elimination with Answers

Question 1.
Presence of RBCs in urine is
(a) Uremia
(b) ketonuria
(c) Glucosuria
(d) hematuria
Answer

Answer: (d) hematuria
Explanation:
Presence of blood in urine is called hematuria.
Presence of glucose in urine is called glucosuria.
Presence of ketone bodies in urine is called ketonuria.
Question 2.
Ornithine cycle leads to the formation of
(a) NH_3
(b) $((NH_2)_2)CO)$
(c) $C_5H_4N_4O_3$
(d) $C_5H_4N_4$
Answer
Answer: (b) $((NH_2)_2)CO)$
Explanation:
Ornithine cycle is the other name of urea cycle. Urea cycle is the production of urea from ammonia.
$((NH_2)_2)CO)$ is the chemical formula of urea.
NH_3 is ammonia.
$C_5H_4N_4$ is purine.
$C_5H_4N_4O_3$ is uric acid.
Question 3.
The yellow pigment derived from heme breakdown and excreted by kidneys is
(a) Uric acid
(b) Urochrome
(c) Cholesterol
(d) Melanin
Answer
Answer: (b) Urochrome
Question 4.
What happens when glomerular filtration rate falls?
(a) Activation of podocytes
(b) Release of renin
(c) Repression of juxta glomerular cells
(d) None of the above
Answer
Answer: (b) Release of renin
Explanation:

Fall in GFR activates juxta glomerular cells to release renin which stimulates glomerular blood flow and brings back the GFR to normal.
Question 5.
Which of the following can be cured by hemodialysis?
(a) Renal calculi
(b) Glomerulonephritis
(c) Uremia
(d) All of these can be cured by hemodialysis
Answer
Answer: (c) Uremia
Explanation:
Malfunctioning of kidneys can lead to accumulation of urea in blood, this situation leads to uremia.
This can lead to kidney failure. In such patients, urea can be removed by hemodialysis.
Question 6.
Kidneys are located in
(a) thoracic cavity
(b) abdominal cavity
(c) body cavity
(d) pelvic cavity
Answer
Answer: (b) abdominal cavity
Explanation:
Kidneys are present in abdominal cavity along with digestive organs.
Body cavity contains brain and spinal cord.
Thoracic cavity contains heart and lungs.
Pelvic cavity contains bladder and reproductive organs.
Question 7.
The muscular tubes which take the urine from the kidneys to the bladder are
(a) Urinary bladders
(b) Ureters
(c) Urethras
(d) Nephrons
Answer
Question 8.
Most water and salts are reabsorbed in
(a) DCT

(b) Bowman s capsule
(c) PCT
(d) DCT and PCT
Answer
Answer: (c) PCT
Explanation:
Maximum absorption of water and salts occurs in proximal convulated tubule.
Question 9.
Reabsorption of filtrate occurs in
(a) renal tubules
(b) glomerular apparatus
(c) medullary pyramid
(d) juxta cells
Answer
Answer: (a) renal tubules
Explanation:
Nearly 99 per cent of the filtrate is absorbed by renal tubules.
Question 10.
JG cells release
(a) angiotensin II
(b) aldosterone
(c) renin
(d) ANF
Answer
Answer: (c) renin
Explanation:
A fall in glomerular blood flow activates JG cells to release renin.
Question 11.
pH of human urine is
(a) 7.0
(b) 6.5
(c) 6.0
(d) 7.5
Answer
Answer: (b) 6.5
Explanation:
The average pH of human urine is 6.0.
Question 12.
Average blood filtered by kidneys per minute is

(a) 1000 – 1500 mL
(b) 500 – 600 mL
(c) 200 – 300 mL
(d) 1100 – 1200 mL
Answer
Answer: (d) 1100 – 1200 mL
Explanation:
On an average kidneys filter 1100 – 1200 mL of blood per minute.
Question 13.
Kidneys are located in
(a) thoracic cavity
(b) abdominal cavity
(c) body cavity
(d) pelvic cavity
Answer
Answer: (b) abdominal cavity
Explanation:
Kidneys are present in abdominal cavity along with digestive organs.
Body cavity contains brain and spinal cord.
Thoracic cavity contains heart and lungs.
Pelvic cavity contains bladder and reproductive organs.
Question 14.
Which one of the following statements in regard to the excretion by the human kidneys is correct?
(a) Ascending limb of Loop of Henle is impermeable to electrolytes
(b) Descending limb of Loop of Henle is impermeable to water
(c) Distal convoluted tubule is incapable of reabsorbing HCO_3
(d) Nearly 99 percent of the glomerular filtrate is reabsorbed by the renal tubules
Answer
Answer: (d) Nearly 99 percent of the glomerular filtrate is reabsorbed by the renal tubules
Question 15.
In the kidneys, osmotic pressure controls _______.
(a) Glucose absorption
(b) Sodium absorption
(c) Water absorption
(d) none of these
Answer
Answer: (c) Water absorption

Question 16.
Presence of ___________ in urine indicates diabetes mellitus.
(a) Glucose
(b) Cholesterol
(c) Ketone bodies
(d) Both 1 and 3
Answer
Answer: (d) Both 1 and 3
Explanation:
Presence of ketone bodies and glucose in urine indicates diabetes mellitus.
Question 17.
If a man takes large amount of protein, he is likely to excrete more amount of
(a) Glucose
(b) Urea and uric acid
(c) Water
(d) Salts
Answer
Answer: (b) Urea and uric acid
Question 18.
Nerves, blood vessels and ureter enters into the kidney through
(a) calyces
(b) hilum
(c) capsule
(d) cortex
Answer
Answer: (b) hilum
Explanation:
Nerves, blood vessels and ureter enters into the kidney through hilum.
Question 19.
The principal nitrogenous excretory compound in humans is synthesised
(a) In the liver but eliminated mostly through kidneys
(b) In kidneys but eliminated mostly through liver
(c) In kidneys as well as eliminated by kidneys
(d) In liver and also eliminated by the same through bile
Answer
Answer: (a) In the liver but eliminated mostly through kidneys
Question 20.
The renal medulla consists of cone-shaped tissue masses called ________.
(a) Renal pyramid

(b) Adipose capsule
(c) Renal cortex
(d) Renal pelvis
Answer
Answer: (a) Renal pyramid

Solutions for Class 11 Biology Chapter 19 Excretory Products and their Elimination:

Section Name	Topic Name
19	Excretory Products and their Elimination
19.1	Human Excretory System
19.2	Urine Formation
19.3	Function of the Tubules
19.4	Mechanism of Concentration of the Filtrate
19.5	Regulation of Kidney Function
19.6	Micturition
19.7	Role of other Organs in Excretion
19.8	Disorders of the Excretory System
19.9	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1.Define Glomerular Filtration Rate (GFR).
Solution. The amount of filtrate formed by the kidneys per minute is called glomerular filtration rate (GFR). It is approximately 125 mL/min. in a healthy person.

2.Explain the autoregulatory mechanism of GFR.
Solution. The kidneys have built-in mechanisms for the regulation of glomerular filtration rate. One such efficient mechanism is carried out by juxta glomerular apparatus (JGA). JGA is a special sensitive region formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact. A fall in GFR can activate the JG cells to release renin which can stimulate the glomerular blood flow and thereby the GFR back to normal.

3.Indicate whether the following statements are true or false.
(a) Micturition is carried out by a reflex.

(b) ADH helps in water elimination, making the urine hypotonic.
(c) Protein-free fluid is filtered from blood plasma into the Bowman's capsule.
(d) Henle's loop plays an important role in concentrating the urine.
(e) Glucose is actively reabsorbed in the proximal convoluted tubule.
Solution.(a) True (b) False (c) True (d) True (e) True

4.Give a brief account of the counter current mechanism.
Solution. The kidneys have a special mechanism for concentrating the urine, it is called counter current mechanism. The mechanism is said to be a counter current mechanism because the out flow (in the ascending limb) of Henle's loop runs parallel to and in the opposite direction of the inflow (in the descending limb) and vasa recta. As the mechanism begins to function, the ascending limb of loop of Henle actively transports chloride and sodium ions out into the vasa recta from where it is secreted into the interstitial fluid. As a result the interstitial fluid around the loop of Henle contains large quantities of NaCl. The filtrate passes from the ascending limb of loop of Henle and enters a collecting duct. The collecting duct passes adjacent to the loop of Henle where the interstitial fluid contains large amounts of NaCl. The high osmotic pressure created by NaCl causes water to diffuse out of the collecting duct in the interstitial fluid and eventually to the blood of vasa recta. The filtrate becomes greatly concentrated and is now called urine. A similar counter current mechanism, operates between the interstitial fluid and blood passing through the vasa recta. As the blood capillary runs along the ascending limb of loop of Henle, NaCl diffuses out of the blood. The direction is reversed as the blood capillary passes along the descending limb of Henle. The blood flows in the vasa recta around the loop of Henle from ascending to the descending side while the fluid passing through the loop of Henle goes in the opposite direction. The arrangement helps to maintain the concentration gradient of NaCl.
The 'overall function of counter current mechanism is to concentrate sodium chloride in the interstitial fluid and thereby cause water to diffuse out of the collecting ducts and concentrate the urine.

5.Describe the role of liver, lungs and skin in excretion.
Solution. Other than the kidneys, lungs, liver and skin also help in the elimination of excretory wastes. Lungs remove large amounts of C02 (18 litres/day) and also significant quantities of water every day. Liver secretes bile which contains substances like bilirubin, biliverdin, cholesterol, degraded steroid hormones, vitamins and drugs. Most of these substances ultimately pass out along with

digestive wastes. The sweat and sebaceous glands in the skin can eliminate certain substances through their secretions. Sweat produced by the sweat glands is a watery fluid containing NaCl, small amounts of urea, lactic acid etc. Sebaceous glands eliminate certain substances like sterols, hydrocarbons and waxes through sebum.

6.Explain micturition.

Solution. The process of passing out urine from the urinary bladder is called micturition. Urine formed by the nephrons is ultimately carried to the urinary bladder where it is stored. This causes stretching of the wall of bladder that leads to the stimulation of stretch receptors on the walls of the bladder. This sends signal to the CNS. The CNS passes on motor messages to initiate the contraction of smooth muscles of the bladder and simultaneous relaxation of the urethral sphincter causing the release of urine.

7.Match the items of column I with those of column II.

Column I	Column II
(a) Ammonotelism	(i)Birds
(b) Bowman's capsule	(ii)Water reabsorption
(c) Micturition	(iii)Bony fish
(d) Uricotelism	(iv)Urinary bladder
(e) ADH	(v)Renal tubule

Solution. (a) – (iii), (b) – (v), (c) – (iv), (d) – (i), (e) – (ii)

8.What is meant by the term osmoregulation?

Solution. The regulation of water and solute contents of the body fluids by the kidney is called osmoregualtion.

9.Terrestrialanimalsaregenerallyeitherureotelic or uricotelic, not ammonotelic, why?

Solution. Ammonotelic animals are aquatic animals that excrete ammonia which is highly soluble in water, thus large amount of water is also excreted. Terrestrial animals cannot afford to lose such large quantities of water from their bodies as they live in environment having water scarcity. They, therefore, excrete either urea (ureotelic) or uric acid (uricotelic) as these are less soluble in water.

10. What is the significance of juxta glomerular apparatus (JGA) in kidney function?

Solution. Juxta glomerular apparatus (JGA) is a special sensitive region formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact. The JGA plays a complex regulatory role. A fall in glomerular blood flow/ glomerular blood pressure/GFR can activate the JG cells to release renin which converts angiotensinogen in blood to angiotensin I and further to angiotensin II. Angiotensin II, being a powerful vasoconstrictor, increases the glomerular blood pressure and thereby GFR. Angiotensin II also activates the adrenal cortex to release aldosterone. Aldosterone causes reabsorption of Na^+ and water from the distal parts of the tubule. This also leads to an increase in blood pressure and GFR.

11 .Name the following.

(a) A chordate animal having flame cells as excretory structures.

(b) Cortical portions projecting between the medullary pyramids in the human kidney.

(c) A loop of capillary running parallel to the Henle's loop.

Solution. (a) Cephalochordate – Amphioxus

(b) Columns of Bertini

(c) Vasa recta

12.Fill in the gaps.

(a) Ascending limb of Henle's loop is________to water whereas the descending limb is________to it.

(b) Reabsorption of water from distal parts of the tubules is facilitated by hormone________

(c) Dialysis fluid contains all the constituents as in plasma except________

(d) A healthy adult human excretes (on an average)________gm of urea/day.

Solution.

(a) Ascending limb of Henle's loop is <u>impermeable</u> to water whereas the descending limb is <u>permeable</u> to it.

(b) Reabsorption of water from distal parts of the tubules is facilitated by hormone <u>ADH.</u>

(c) Dialysis fluid contains all the constituents as in plasma except <u>nitrogenous wastes.</u>

(d) A healthy adult human excretes (on an average) <u>25 – 30</u> gm of urea/day.

Locomotion and Movement Class 5 Notes Biology Chapter 20

Topic 1 Musculature : Structure and Functions

Movement
Movement is defined as any visible change of position, exhibited either by the whole organism or any part of the body. It is one of the important characteristics of living organisms.
The movement of living things are autonomic (self-sustained) while, the movement of non-living objects is induced (due to external forces). Both animals and plants exhibit wide range of movements. Movement of animals can be muscular and non-muscular. Plants show cellular and often organ movement, but not the movement of the organism. The study of movement is called Kinesiology.

Types of Movement
Three main types of movement are exhibited by the cells of the human body. These are as follows
1. Amoeboid (Pseudopodial) Movement
Movement with the help of finger-shaped protoplasmic extensions (i.e., pseudopodia or false feet) (as seen in Amoeba) is called amoeboid movement, e.g., Movement of leucocytes and macrophages in blood. Cytoskeletal elements, like microfilaments are also involved in this type of movement.

2. Ciliary Movement
Movement with the help of cilia is called ciliary movement. Cilia are short, fine, hair-like structures present all over the body surface in large numbers, which beat in succession in coordinated manner to help in locomotion, e.g., Removal of dust particles and foreign substances through the trachea, passage of ova through female reproductive tract.

This type of movement occurs in most of our internal tubular organs that are lined by ciliated epithelium.
The above two movements are called non-muscular movements.

3. Muscular Movement
Movement with the help of muscles is called muscular movement. These are brought about by the movement of myofilaments packed within the muscle fibres. The contractile property of muscles is used effectively to bring about a movement. This type of movement is found in majority of multicellular animals including humans.

Locomotion
It is the movement of an animal as a whole from one place to another. These are vpluntary movements that results in change of place or location. It requires a perfect coordinated activity of muscular, skeletal and neural system. Locomotion takes several forms such as walking, running, flying, swimming, etc.

Advantages of Locomotion
It helps the animal in search of food, shelter, mate, to escape from enemies/predators, to locate suitable areas for breeding or to disperse to new locations. Methods of locomotion in animals vary with their habitats and the demand of situation.

Locomotion v/s Movement
It is very difficult to separate movement from locomotion because an animal cannot change its place (locomotion) without movement, e.g., Cilia helps in movement of food inside cytopharynx and in locomotion in Paramecium. Tentacles in Hydra are used for capturing prey and in locomotion.

Limbs are used for change of body postures as well as for locomotion in humans. This suggests that movements and locomotion are interlinked thus, stating that all locomotions are movements but all movements are not locomotions.

Muscles
These are made up of highly specialised thin and elongated cells called muscle fibres. Muscles arises from the embryonic mesoderm. It makes about 40-50% of a human body weight.

Special Properties
Muscles exhibit various special properties, some of them are given below
(i) Contractibility The cells of muscle can be shorten considerably and return to the original relaxed state.
(ii) Excitability It is due to the energy stored in the electrical potential difference across the plasma membrane.
Other distinguishing properties are extensibility and elasticity.

Note:

- Muscle Tissue is the most abundant tissue in most animals.
- Human body has some 639 separate muscles that bring about movement in majority of animals.
- The study of muscle is called Myology.
- Muscles of iris and ciliary body are ectodermal in origin.
- The largest/biggest muscle in human body is gluteus maximus (hip muscle), the longest muscle is sartorius (back muscle), the strongest muscle is masseter (jaw muscles).
- The longest smooth muscle is rectus abdomins and the shortest muscle is stapedial muscle.

Types of Muscles
Muscles have been classified using different criteria,
i. e., location, appearance and nature of regulation of their activities.
Based on their location, the muscles are of three types, i.e., skeletal, visceral and cardiac.
i. Skeletal or Striated Muscles
It functions in association with the skeleton of organism. Under the microscope, they have a striped appearance and hence are called striated muscles.
They are also known as voluntary muscles as their activities are under the voluntary control of the nervous system. The major component of muscles is water and potassium is the most abundant mineral element.
They are primarily involved in locomotory actions and change of body postures.

ii. Visceral or Smooth Muscles
They are found in the inner walls of hollow visceral (internal) organs of body like alimentary canal, reproductive tract, etc.

They do not exhibit any striation, i.e., smooth in appearance and hence, are called smooth muscles (non-striated muscle). They are also known as involuntary muscles as they are not under the voluntary or direct control of the nervous system.

They assist in the transportation of materials, e.g., Movement of food through the digestive tract and gametes through the genital tract.

iii. Cardiac Muscles
It occurs in the wall of the heart and in walls of large veins (e.g., Pulmonary veins and superior vena cava), where these veins enter the heart. These are striated and involuntary in nature. Oblique bands and intercalated discs are their characteristic feature.
It assembles in a branching pattern to form a cardiac muscle. They never get fatigued.

Note:

- Two types of muscles fibres are found in the body. Slowtwitch (in muscles that require endurance) and fast twitch (in muscles that contract quickly.)
- High intensity exercise causes an increase in muscle mass, while low intensity exercise, aerobic exercise, build mass, but do not burn colonies.

Detailed Structure of a Skeletal Muscle

Skeletal muscle is made up of a numbed of muscle bundles or fascicles held together by fascia (collagenous connective tissue layer). (plasma membrane) and contains well developed endoplasmic reticulum (sarcoplasmic reticulum), specialised for calcium storage in its sarcoplasm (cytoplasm).

Muscle fibre is a syncitium as the sarcoplasm contains many nuclei. There are large number of parallely arranged filaments called myofilaments or myofibrils (characteristic feature of muscle fibre).

Detailed Study of a Myofibril
A myofibril has alternate dark and light bands. The dark bands are also called A-band (anisotropic band) and contains protein myosin. The light bands are also called I-band (isotropic band) and contains actin.

The striated appearance of myofibril is due to the distribution pattern of the proteins actin and myosin. Both these proteins are arranged as rod-like structures, parallel to each other and also to longitudinal axis of myofibrils. Actin filaments are thinner than myosin filaments, hence are usually called thin and thick filaments respectively.

Composition of Muscle Bundle

Each muscle bundle contains a number of muscle fibres (muscle cells), bounded by sarcolemma

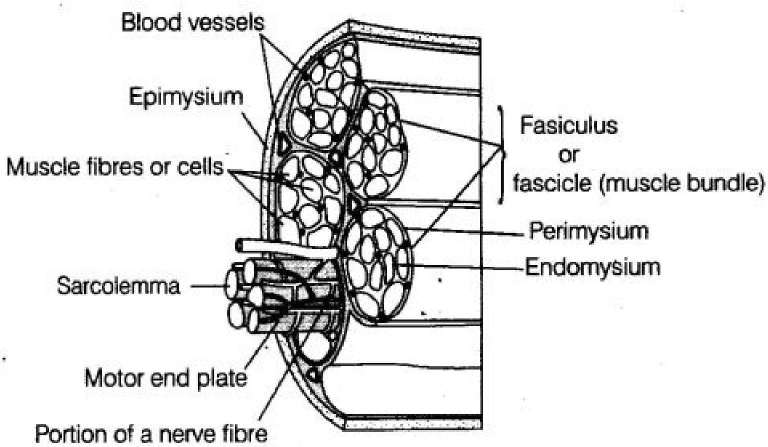


Fig. 20.1 Diagrammatic cross sectional view of a muscle showing muscle bundles and muscle fibres

Each I-band has its centre, a dark membrane called Z-line (an elastic fibre). It is also called Z-disc or Krause's membrane or Dobie's line. The part of the myofibril between two successive Z-lines is a called a sarcomere (functional unit of contraction). A sarcomere consists of the A-band and half of each adjacent I-band. A thin fibrous membrane called M-line present in the middle of A-band holds the thick filaments together.

The A and I-bands are arranged alternately throughout the length of myofibril. At the centre of A-band, a portion is present that is not overlapped by thin filaments. It is called the H-zone (Hensen zone).

In resting state, the edges of thin filaments on either side of thick filaments partially overlap each other leaving H-zone in the centre of thick filaments.
Structure ot Contractile Proteins

The thick myofilaments are formed by myosin protein. The thin myofilaments are formed by three types of proteins called actin, tropomyosin and troponin. These four proteins are collectively known as contractile proteins.

Thick Myofilament or Primary Myofilament
It consists mainly of myosin protein. Each myosin filament is a polymerised protein, made up of many monomeric proteins called meromyosins.
Each meromyosin has two important parts as follows

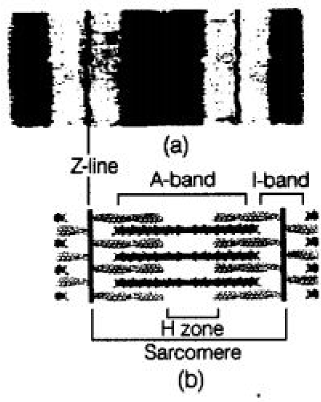


Fig. 20.2 Diagrammatic representation of
(a) Anatomy of a muscle fibre showing a sarcomere
(b) A sarcomere

Globular Head
It has a short arm, called heavy meromyosin (HMM). The HMM components projects outwards at regular distance and angle from each other, from surface of a polymerised myosin filament and known as cross arm. The globular head is an active ATPase enzyme, which has binding sites for ATP and active sites for actin.

Tail
Tail is called the light meromyosin (LMM). The myosin molecule has two identical heavy chains and four light chains. The two heavy chairis wrap spirally around each other to form a double helix. The light chains are the parts of the myosin heads and help control the function of head during the contraction of muscle.

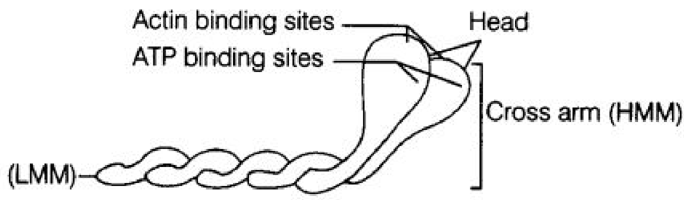


Fig. 20.3 Myosin monomer (meromyosin)

Thin Myofilament or Secondary Myofilament
It is composed of following proteins Actin

It is a globular protein with low molecular weight. It is made up of two 'F' (filamentous) actin helically wound to each other. Each F actin is a polymer of monomeric 'G' (globular) actins.

Tropomyosin
Two filaments of. this protein run close to the 'F' actions throughout its length.

iii. Troponin
It is a complex protein of three globular peptides (Troponin T, Troponin-I and Troponin-C) distributed at regular intervals on tropomyosin.

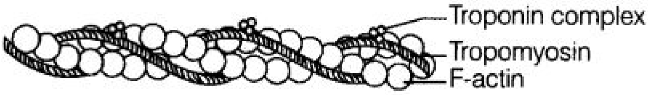


Fig. 20.4 An actin (thin) filament

In the resting stage of muscle fibre, a subunit of troponin masks the active sites for myosin on the actin filaments.

Note:

- Partial overlapping of primary myofilaments by the secondary myofilaments imparts dark appearance to the A-bands.
- The strong affinity of the troponin for calcium ions is believed to initiate the contraction process.

Mechanism of Muscle Contraction
The contraction of muscle is best explained by the sliding filament theory. It states that contraction of muscles takes place by the sliding of thin and thick filaments that past over each other with the help of cross-bridge to reduce the length of the sarcomere.

This theory was proposed independendy by AF Huxley and R Niedergerke and by HE Huxley and Jean Manson in England in 1954.

The sequence of events leading to contraction is initiated by a signal in the Central Nervous System (CNS), either from the brain (voluntary activity) or from spinal cord (reflex activity) via a motor neuron.

A motor neuron along with the muscle fibres connected to it, forms a motor unit and the action potential is conveyed to a motor end plate (or neuromuscular junction) i.e., the junction between a motor neuron and sarcolemma of muscle fibre) on each muscle fibre.

A neurotransmitter (acetylcholine) is released at the junction by the neural signal which generates an action potential in the sarcolemma. This spreads and causes the release of calcium ions into sarcoplasm.
Calcium plays a key regulatory role in muscle contraction. Increase in calcium ions level leads to their binding to troponin subunit. Thus, exposing the active sites on F-actin molecules.

Formation of Cross-Bridge
An ATP molecule joins the active site on myosin head of myosin myofilament. These heads contains an enzyme, myosin ATPase that along with Ca^{2+} and Mg^{2+} ions catalyses the breakdown of ATP.

$$\text{ATP} \xrightarrow[Ca^{2+},\, Mg^{2+}]{\text{Myosin ATPase}} \text{ADP} + \text{Pi} + \text{Energy.}$$

The energy is transferred to myosin head, which energises and straightens to join an active site on actin myofilament, forming a cross bridge.

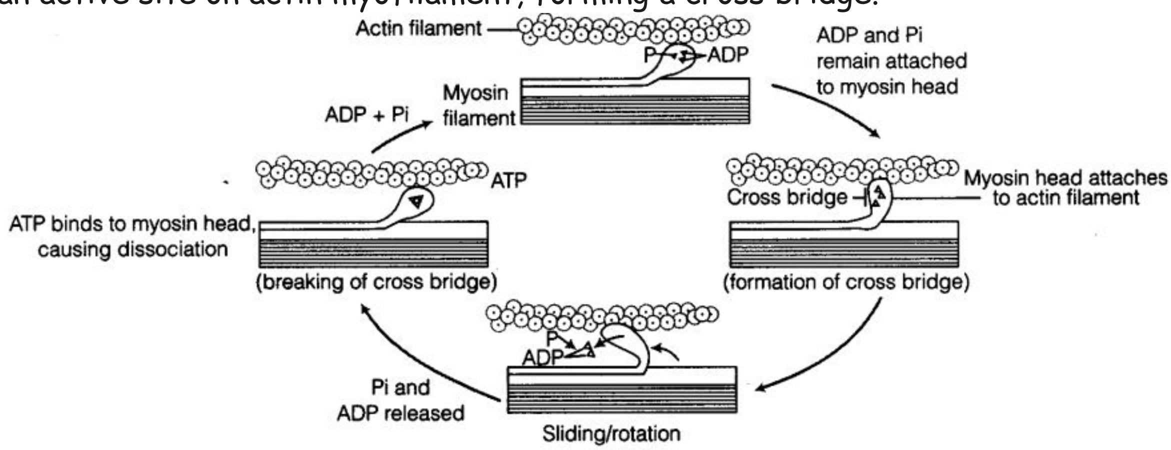


Fig. 20.5 Stages in cross-bridge formation, rotation of head and breaking of cross-bridge

The energised cross-bridges move, causing the attached actin filaments to move towards the centre of A-band. The Z-line is also pulled inwards causing shortening of sarcomere, i.e„ contraction. It is clear from the above explanation that during contraction A-bands retain the length, while I-bands get reduced.

The myosin head releases ADP and Pi, relaxes to its low energy state. The head detaches from actin myofilaments when new ATP joins it (cross-bridge broken).

In repeating cycle, the free head cleaves the new ATP. The cycles of cross bridge formation and breakage is repeated causing further sliding.

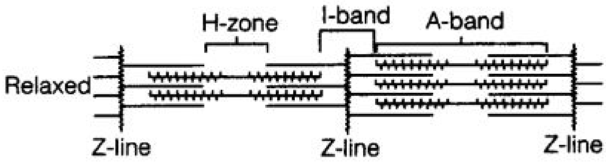


Fig. 20.6 Sliding filament theory of muscle contraction (movement of the thin filaments and the relative size of the I-band and H-zones)

Muscle Relaxation

After contraction the calcium ions are pumped back to the , sarcoplasmic cisternae, blocking the active sites on actin myofilaments. The Z-line returns to original position, i.e., relaxation.

Note:

Rigor Mortis is the state of body stiffening after death due to non-separation of actin and myosin filaments caused by non-availibility of ATP. It appears first in the small muscles of the face (such as jaw) and those being used most actively prior to death. It persists till decomposition starts.

Red and White

Birds and mammals have two kinds of striated muscle fibres, in their skeletal muscles, i.e., red (or slow) and white (or fast) muscle fibres.

Differences between Red and White Muscle Fibres

Red Muscle Fibres	White Muscle Fibres
They are dark red muscle fibres due to the presence of abundant myoglobin in them.	They are pale or whitish as they have less myoglobin.
Mitochondria are more in number, but they have less sarcoplasmic reticulum.	Mitochondria are few in number, but amount of sarcoplasmic reticulum is high.
They depend on aerobic process for energy.	They depend on anaerobic process for energy.
They have slow rate of contraction for long periods.	They have fast rate of contraction for short periods.
e.g., Extensor muscle of the human back.	*e.g.*, Eye ball muscles.

Topic 2 Skeletal System : Structure, Functions and Disorders

Skeleton (Skeletal System)

The hard, supportive or protective elements of the animal body constitute the skeletal system or skeleton. It consists of a framework of bones and a few cartilages. Both of them are specialised connective tissues.
Bone has a very hard matrix due to calcium salts and made up of a protein called ossein.

Cartilage has slightly pliable matrix due to chondroitin salts. It is made up of a protein called chondrin.
Bone consists of a dense outer layer known as compact bone and spongy layer inside called spongy bone.
Bones are remodeled for strength when exposed to new stresses.

Functions of Skeleton

Skeleton serves to perform following functions
(i) Support It gives support to softer body parts.
(ii) Protection It protects the delicate internal organs like brain, heart, lungs, etc.
(iii) Muscle attachment Provide surface for attachment of muscles.
(iv) Movement Bones helps in bringing about movements also.
(v) Blood cell formation To manufacture blood corpuscles in bone marrow.
(vi) Helps in breathing and hearing Tracheal rings, sternum and ribs are helpful in breathing, while ear bones (middle ear) transmit sound vibrations.

Human Skeleton

Human body is made of 270 bones, which are fused variously to form 206 bones.
On the basis of the position of the skeletal structures in the body, the endoskeleton is divisible into two parts
(i) Axial skeleton It comprises of 80 bones, which
includes skull, vertebral column, ribs and sternum.
(ii) Appendicular skeleton It lies along the transverse (side) axis. It comprises of 126 bones, which , includes pectoral and pelvic girdles and limb bones, i.e., bones of arms and legs).

Note:

- Bones are of four categories according to size and shape, i.e., long, short, flat and irregular bones.
- Smallest bone is Stapes.
- Longest and strongest bone is Femur.
- Funny bone is Olecranon process on top of the ulna.
- There are remarkable differences in the skull of male and female, thus, together with the pelvis it is used for identification of sex.

Skull
It is the bony framework of the head. It is composed of two set of bones (cranial and facial) that forms total of 22 bones [bones of middle ear (6 bones) and hyoid bone (1) are also included in bones of skull].

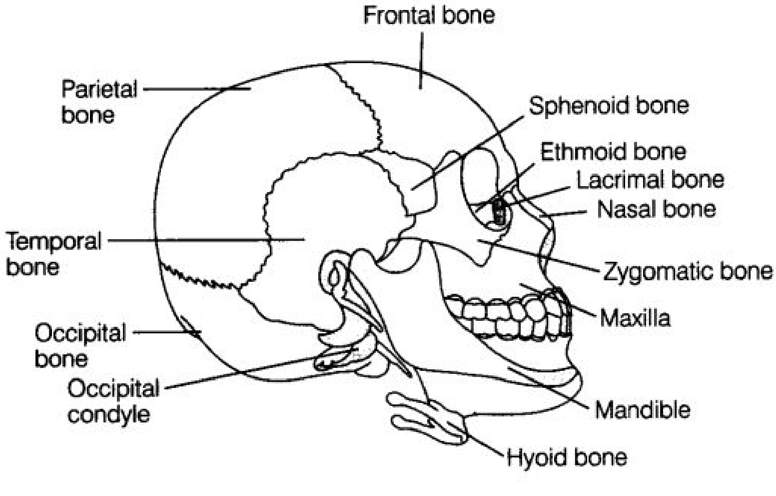


Fig. 20.7 Diagrammatic view of human skull

Bones of skull are as follows
(i) Cranium — 8 includes frontal (1), parietal (2), temporal (2), occipital (1), sphenoid (1), ethmoid (1). They form the hard protective outer covering (cranium) for the brain
(ii) Facial bones — 14 includes maxillae (2), palatine (2) mandible (1), vomer (1), nasal (2), zygomatic (2), lacrimal (2), inferior turbinate (2)

They form the front part of the skull
(iii) Ear ossicles — 6 includes, 2 malleus, 2 incus, 2 stapes
These three tiny bones belong to the middle ear.

(iv) Hyoid A U-shaped bone present at the base of buccal cavity. It is the only bone which is not in contact with the another bone. This is also called tongue bone.

Human skull is dicondylic, the skull region articulates with vertebral column with the help of two occipital condyles.

Vertebral Column
It is also called backbone or spine. It is dorsally placed, extending from the base of the skull and constitutes the main framework of the trunk.

It is made of, 26 serially arranged units called vertebrae.It includes cerical or yes bone (7), Thoracic
(12), Lumbar (5), Scaral or Sacrum (1-fussed) and
coccygeal (1-fused). The vertebral formula for humans is $C_7, T_{12}, L_5, S_5, C_{(3-5)}$.

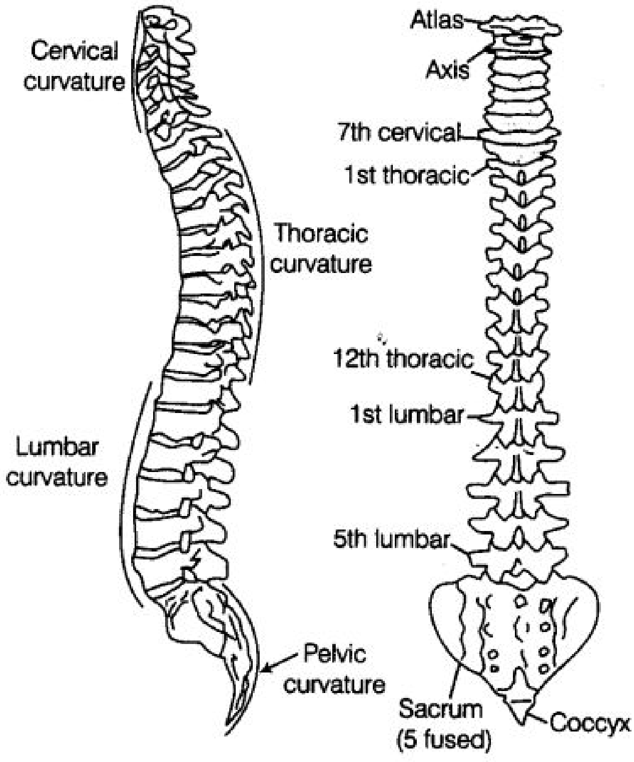


Fig. 20.8 Vertebral column (human)

Note:

- Altas is the first vertebra and it articulate with the occipital condyles.
- The number of cervical vertebrae is 7 in almost all mammals).
- Lumbar is the largest and the strongest in the vertebral column.

Vertebral column performed following junctions
(i) provides protection to the spinal cord,
(ii) supports the head,

(iii) allows flexion and bending of the back and body
(iv) also serves as point of attachment for the ribs.

Sternum
It is a flat daggar-shaped bone located on the ventral midline of thorax.

Ribs
These are the thin, flat curved bones that form a protective cage around the organs of upper body. The ribs are composed of 24 bones arranged in 12 pairs, connected dorsally to thoracic vertebrae and ventrally to sternum by hyaline cartilage. It has two articulation surfaces on its dorsal end and hence called bicephalic.

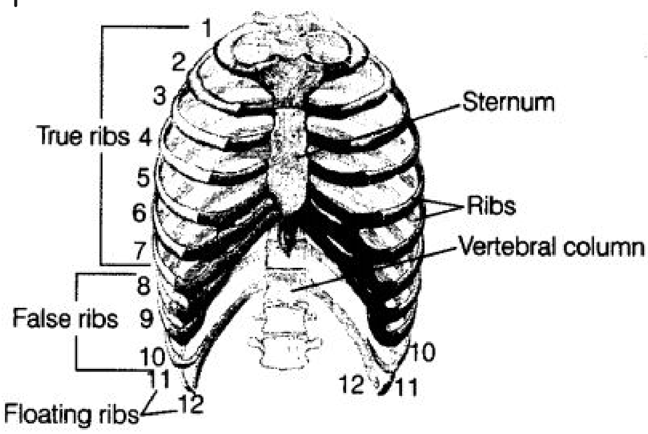


Fig. 20.9 Ribs and rib cage

Ribs are mainly categorised into following types

True Ribs
The first seven ribs are attached directly with the sternum and are called true ribs.

False Ribs
The 8th, 9th and 10th pairs of ribs join the seventh rib with the help of hyaline cartilage. They do not articulate directly with sternum. Hence, are called vertebrochondral (false) ribs.

Floating Ribs
The last two (11th and 12th) pairs of ribs remains free anteriorly and are called floating ribs.
(i) they protect the heart, large blood vessels and lungs.

(ii) bear respiratory muscles.
(iii) also lower two pairs of ribs also protect the kidneys.
Thoracic vertebrae, ribs and sternum together form the rib cage.

Limbs

The bones of the limbs alongwith gridles constitute the appendicular skeleton. Each limb is made of 30 bones.

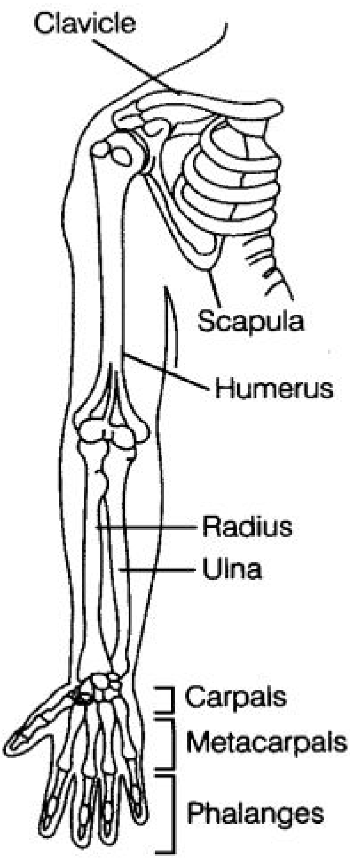


Fig. 20.10 Right pectoral girdle and upper arm (frontal view)

Forelimb
The bones of the hand (forelimb) constitutes
Humerus (1), Radius (1), Ulna (1), Carpals/wrist bones (8),
Metacarpals-palm bones (5) and phalanges/digits (14).
The humerus and ulna together make up the below.
The ulna is longer than the radius and connects more firmly to the humerus.

The radius contributes to the movement of the wrist.
The phalangeal formula for human hand is 2, 3, 3, 3, 3.

Pectoral (Shoulder) Girdle
It consists of following two bones, i.e., scapula and clavicle.
i. Scapula (Shoulder Blade)
It consists of a sharp ridge the spine and a triangular body. The end of spine projects as a flattened and expanded portion called acromion. This articulates with the clavicle.

Glenoid cavity is a depression below the acromian to which head of humerus articulates forming shoulder joint.

ii. Clavicle (Collar Bone)
Each clavicle is a long slender bone with two curvatures. The clavicle helps in articulation of the upper limb with axial skeleton.

This provides an attachment point for numerous muscles that allow shoulder and elbow joints to move.

Hindlimb
The bones of the leg (hindlimb) constitutes
Femur (1), Tibia (1), Fibula (1), Tarsals (7), Metatarsals (5)
and phalanges (14).

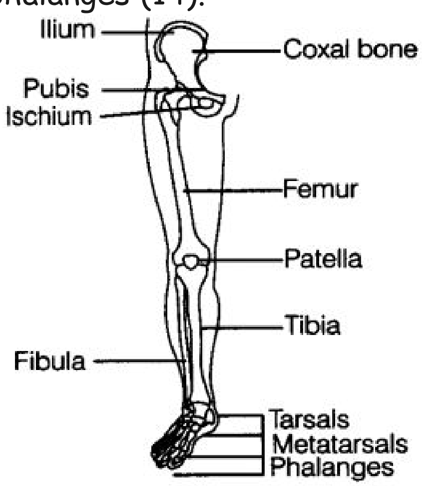


Fig. 20.11 Right pelvic girdle and lower limb bones (frontal view)

A cup-shaped bone called patella cover knee ventrally. It is a seasmoid bone (bone

embedded within a tendon). Femur, tibia and fibula bones together support the shank of leg. Tarsals form the ankle, metatarsals form the sole and phalanges form the digits of the foot.
The phalangeal formula for human foot is 2, 3, 3, 3, 3.

Pelvic (Hip) Girdle
It is located in the lower part of the trunk. It consists of two coxal (hip) bones. Each coxal is also known as ossa coxae or innominate bone. This is formed by fusion of the following three bones
(i) Upper ilium (ii) Lower ischium
(iii) Inner pubis

The innominate at the middle of its lateral surface has a deep, cup-shaped acetabulum, where head of femur articulates. The two halves of the pelvic girdle meet ventrally to form pubic symphysis containing fibrous cartilage.
It provides articulation to the bones of the leg, supports and protects abdominal viscera. It also provides attachment to certain leg muscles.

Joints
The place of articulation between two or more bones or between a bone and a cartilage is called a joint.
The study of joints is known as arthrology.

Classification of Joints
There are three major structural forms, i.e., fibrous, cartilaginous and synovial.
Fibrous (Immovable Joints)
They do not allow movement because the bones are held firmly by bundles of dense white fibrous tissue.
e.g., The sutures (joints between the bones of skull) and syndesmosis (joint between tibia and fibula).

Cartilaginous (Slightly Movable Joints)
They allow slight movement because of the elastic pads of fibrocartilage present between the ends of the bones taking part in the joints, e.g., Pubic symphysis of pubis, the joints between the adjacent vertebrae in the vertebral column.

Synovial (Freely Movable Joints)
A considerable movement is allowed at all synovial joints. They are surrounded by tubular articular capsule.
The capsule consists of two layers, i.e., outer fibrous capsule and inner synovial membrane which secretes synovial fluid' that lubricates and is responsible for providing nourishment to articular cartilage.
In old age, stiffness of joints is due to decrease in synovial fluid.

According to shape of bones and types of movement, the synovial joints are of following six types
(i) Ball and Socket Joint In this type, a ball-like structure on one bone fits into a socket like structure in another bone, e.g., Shoulder joint (between pectoral girdle and head of humerus) and hip joint (between acetabulum and head of femur).

(ii) Hinge (Knee) Joint This joint allows the movement in one plane only, e.g., Elbow, knee, ankle and interphalangeal joints.

(iii) Pivot Joint This joint is responsible for providing movement in one plane, e.g., Joint between atlas and axis and radioulnal joint (between radius and ulna).

(iv) Gliding Joint This joint allows limited movement in all direction as the bones are closely packed together or held in place by ligaments, e.g., Joints between the carpal bones and between the tarsal bones.

(v) Saddle Joint This type of joint is like ball and socket joint but not developed fully, e.g., Joint between carpal of hand and metacarpal of thumb.

(vi) Condyloid or Ellipsoid Joint This allows movement in two planes (i.e., back-forth and side-side), e.g., joint between metacarpals and phalanges (metacarpophalangeal joint) of the fingers.

Some Common Injuries of the Joints
Partially or completely torn ligament.
Dislocation Occurs when bones are forced out of a joint, often accompanied by sprains, inflammation and joint immobilisation.
Cartilage tears Cartilage may tear when joints are twisted or when pressure is applied to them.

Some Common Injuries of the Joints

Sprain	Partially or completely torn ligament.
Dislocation	Occurs when bones are forced out of a joint, often accompanied by sprains, inflammation and joint immobilisation.
Cartilage tears	Cartilage may tear when joints are twisted or when pressure is applied to them.

Functions of Joints

Joints serves following functions in human body

(i) These are essential for all types of movement.

(ii) Force generated by muscles is used to carry out movement through joints, where joints acts as a fulcrum.

(iii) The joints make body flexible.

(iv) Some joints allow the growth of the structures that they connect to.

Disorders of Muscular and Skeletal System

Myasthenia Gravis

It is a chronic, autoimmune, neuromuscular disease characterised by varying degrees of weakness in the skeletal muscles of body. It leads to fatigue and ultimately to paralysis of skeletal muscles.

a. Muscular Dystrophy

It is an inborn (genetic) disorder of muscles associated with dysfunction and ultimately with deterioration. The patient is unable to walk after the age of 12, death usually by the age of 20.

Tetany

It is an abnormal condition characterised by periodic painful muscular spasms (wild contractions) and tremors. It is caused by low calcium levels in body fluid and associated with diminished function of parathyroid gland.

Arthritis

It is caused by inflammation of the joints. It is of several types, some of them are as follows

(a) Rheumatoid Arthritis It is an inflammation of the synovial membrane in synovial joints, may seem to occur at any age.

(b) Osteoarthritis/Degenerative Joint Disease It is characterised by progressive

erosion of articular cartilage at synovial joint.
(c) Infectious Arthritis It is a form of joint inflammation caused by a microorganism (such as bacterium, virus or a-fungus).
(d) Gout/Gouty Arthritis It is the type of arthritis that occurs mainly due to defect or accumulation of uric acid crystals.

Note:

- Still's disease (Juvenile rheumatoid arthritis) is another kind of rheumatoid arthritis that occurs in younger people
- There is no cure for this type of arthritis. However, pain releiving (analgesic) drugs are available to give comfort.

b. Osteoporosis
In this, a reduction in bone tissue mass occurs, causing weakness of skeletal strength. It results from excessive resorption of calcium and phosphorus from the bone, decreased level of oestrogen is a common cause for this
(a) It is an age-related disorder that is more common in women than in men.
(b) It leads to increased chances of fractures.

Locomotion and Movement Class 5 MCQs Questions with Answers

Question 1.
Metacarpals are present in
(a) wrist
(b) palm
(c) digits
(d) thigh
Answer
Answer: (b) palm
Explanation:
Metacarpals are palm bone, they are 5 in number.
Question 2.
The elements associated with muscle contraction are
(a) Mg and Ca
(b) Mg and Cl

(c) Na and Ca
(d) Ca and K
Answer
Answer: (c) Na and Ca

Question 3.
What happens in osteoporosis?
(a) Decrease in progesterone
(b) Increase in progesterone
(c) Decrease in estrogen
(d) Both 2 and 3
Answer
Answer: (c) Decrease in estrogen
Explanation:
In osteoporosis, there is decrease in levels of estrogen.

Question 4.
Match the columns.
A. Hinge Joint – 1. Carpals
B. Saddle Joint – 2. Knee
C. Pivot Joint – 3. Thumb
D. Gliding Joint – 4. Vertebra
(a) A-4, B-3, C-1, D-2
(b) A-3, B-1, C-2, D-4
(c) A-2, B-3, C-4, D-1
(d) A-3, B-1, C-4, D-2
Answer
Answer: (c) A-2, B-3, C-4, D-1
Explanation:
Column I shows types of synovial joints. Column II shows the location where these are present.

Question 5.
Coris cycle operates in
(a) Cartilage
(b) Muscle
(c) Liver
(d) Liver and muscle
Answer

Answer: (d) Liver and muscle
Question 6.
One of the following is true of muscle contraction.
(a) H-zone expands
(b) I-band expands
(c) A-Band remains constant
(d) The sarcomeres expands
Answer
Answer: (c) A-Band remains constant

Question 7.
Which cavity is formed by the fusion of coxal bones?
(a) Glenoid cavity
(b) Acetabulum
(c) Acromion
(d) Scapula
Answer
Answer: (b) Acetabulum
Explanation:
There are three coxal bones namely ilium, ischium and pubis.
At the point of fusion of these, a cavity is formed called acetabulum.

Question 8.
Which is a part of pectoral girdle?
(a) Acetabulum
(b) Ilium
(c) Sternum
(d) Glenoid cavity
Answer
Answer: (d) Glenoid cavity

Question 9.
A skeletal muscle which decreases the angle between two bones and bends a joint is
(a) Flexor
(b) Abductor
(c) Extensor
(d) Adductor
Answer

Answer: (a) Flexor

Question 10.
Which one of the following is correct pairing of a body part and the kind of muscle tissue that moves it?
(a) Iris – Involuntary smooth muscle
(b) Heart wall – Involuntary unstriated muscle
(c) Biceps of upper arm – Smooth muscle fibres
(d) Abdominal wall – Smooth muscle
Answer

Question 11.
Largest bone in human body is
(a) Ulna
(b) Femur
(c) Humerus
(d) Tibia
Answer
Answer: (b) Femur

Question 12.
Which one of the following pairs is wrong about cardiac muscles?
(a) Location – only in the heart
(b) Function – Pumping of blood
(c) Gap junctions – No
(d) Striated – Yes
Answer
Answer: (c) Gap junctions – No
Question 13.
What is the ion necessary for muscle contraction?
(a) Cl
(b) Ca
(c) Na
(d) K
Answer
Answer: (b) Ca

Question 14.
Which one of the following is correct pairing of a body part and the kind of muscle

tissue that moves it?
(a) Iris – Involuntary smooth muscle
(b) Heart wall – Involuntary unstriated muscle
(c) Biceps of upper arm – Smooth muscle fibres
(d) Abdominal wall – Smooth muscle
Answer
Answer: (a) Iris – Involuntary smooth muscle

Question 15.
Bones formed by ossification of a tendon is called
(a) Dermal bone
(b) Sesamoid bone
(c) Membrane bone
(d) Cartilage
Answer
Answer: (b) Sesamoid bone

Question 16.
Which joint occurs between humerus and radioulna?
(a) Ball and socket joint
(b) Sliding
(c) Pivot
(d) Hinge joint
Answer
Answer: (d) Hinge joint

Question 17.
Hyoid is a
(a) cavity
(b) cartilage
(c) bone
(d) fluid
Answer

Question 18.
_______ connect the ends of bones together.
(a) Ligaments
(b) Tendons

(c) Muscles
(d) cartilages
Answer
Answer: (a) Ligaments

Question 19.
________ is used to capture prey in Hydra.
(a) Cilia
(b) Flagella
(c) Tentacles
(d) Forelimbs
Answer
Answer: (c) Tentacles
Explanation:
Hydra uses its tentacles to capture prey and for locomotion.

Question 20.
Ilium, ischium, and pubis join at the _______ to form coxal bone.
(a) Acetabulum
(b) Ilium
(c) Sternum
(d) Glenoid cavity
Answer
Answer: (a) Acetabulum

Solutions for Class 11 Biology Chapter 20 Locomotion and Movement:

Section Name	**Topic Name**
20	Locomotion and Movement
20.1	Types of Movement
20.2	Muscle
20.3	Skeletal System
20.4	Joints
20.5	Disorders of Muscular and Skeletal System
20.1	Summary

1. Draw the diagram of a sarcomere of skeletal muscle showing different regions.

Solution:

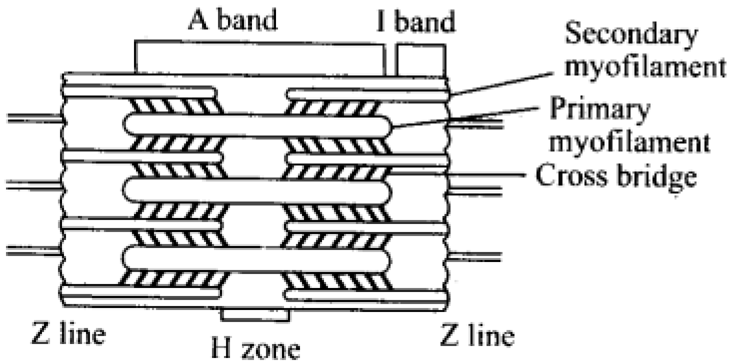


Fig.: Structure of a sarcomere.

2. Define sliding filament theory of muscle contraction.

Solution: According to sliding filament theory of muscle contraction, the actin and myosin filaments slide past each other with the help of cross-bridges to reduce the length of the sarcomeres.

3. Describe the important steps in muscle contraction.

Solution: Mechanism of muscle contraction is explainei by sliding filament theory which states that contraction of a muscle fibre takes place by the sliding of the thin filaments over the th' ck filaments. As a nerve impulse reaches the terminal end of the axon, synaptic vesicles fuse with the axon membrane and release a chemical transmitter, acetylcholine and binds to receptor sites of the motor end plate. When depolarization of the motor end plate reaches a certain level, it creates an action potential. An action potential (impulse) passes from the motor end plate over the sarcolemma and then into the T-tubules and sarcoplasmic reticulum and stimulates the sarcoplasmic reticulum to release calcium ions into the sarcoplasm. The calcium ions bind to troponin causing a change in its shape and position. This in turn alters shape and the position of tropomyosin, to which troponin binds. This shift exposes the active sites on the F-actin molecules. Myosin cross-bridges are then able to bind to these active sites. The heads of myosin molecules project laterally from thick myofilaments towards the surrounding thin myofilaments. These heads are called cross bridges. The head of each myosin molecule contains an enzyme mysoin ATPase. In the presence of myosin ATPase,Ca^{++} and Mg^{++} ions, ATP breaks down into ADP and inorganic phosphate, releasing energy in the head.

Energy from ATP causes energized myosin cross bridges to bind to actin.

$$ATP \xrightarrow[Ca^{++},\ Mg^{++}]{\text{Myosin ATPase}} ADP + Pi + Energy$$

The energized cross-bridges move, causing thin myofilaments to slide along the thick myofilaments.

4. Write true or false. If false change the statement so that it is true.
(a) Actin is present in thin filament.
(b) H-zone of striated muscle fibre represents both thick and thin filaments.
(c) Human skeleton has 206 bones.
(d) There are 11 pairs of ribs in man.
(e) Sternum is present on the ventral side of the body.
Solution: (a) True
(b) False – H-Zone of striated muscle fibres represents only thick filaments.
(c) True
(d) False – There are 12 pairs of ribs in man.
(e) True

5. Write the differences between:
(a) Actin and Myosin
(b) Red and White muscles
(c) Pectoral and Pelvic girdle
Solution: (a) Actin filaments and myosin filaments can be differentiated as follows:

	Actin filaments (Thin myofilaments)	Myosin filaments (Thick myofilaments)
(i)	Found in both A and I bands.	Found only in A band of sarcomere.
(ii)	Thinner (0.005 mm) but shorter (2–2.6 mm) than myosin filaments.	Thicker (0.01 mm) but longer (4.5 mm) than actin filaments.
(iii)	Cross bridges absent, hence have smooth surface.	Cross bridges present, hence have rough surface.
(iv)	More numerous than myosin filaments, six of them surround each myosin filament.	Fewer than actin filaments.
(v)	Free at one end and are joined to Z-line by other end.	Free at both the ends.
(vi)	Consist of 3 proteins : actin, tropomyosin and troponin.	Consist of 2 proteins : myosin and meromyosin.
(vii)	Slide into H-zone during muscle contraction.	Do not slide during muscle contraction.

(b) Differences between red muscle fibres and white muscle fibres are given in the following table:

	Red muscle fibres	White muscle fibres
(i)	They are thin.	They are much thicker.

(ii)	They contain abundant mitochondria, low glycogen content and poorly formed sarcoplasmic reticulum.	They are poor in mitochondria, and have abundant glycogen granules and well formed sarcoplasmic reticulum.
(iii)	They are dark red as they contain abundant pigment myoglobin.	They are light in colour as they have very little myoglobin.
(iv)	Their myoglobin stores O_2 as oxymyoglobin that releases O_2 for oxidation during muscle contraction.	hey have little or no store of oxygen.
(v)	They get energy for contraction by aerobic respiration.	They get energy for contraction mainly by anaerobic respiration.

(vi)	They accumulate little lactic acid.	They accumulate lactic acid during strenuous work.
(vii)	They undergo slow sustained contractions for long periods.	They undergo fast contractions for short periods.
(viii)	They are not fatigued with work	They soon get fatigued with work.
(ix)	They are innervated by thin, slow-conducting nerve fibres. Example : Extensor muscles of the back in man.	They are innervated by thick, fast-conducting nerve fibres. Example : Eyeball muscles.

(c) Differences between pectoral and pelvic girdles are given in the following table:

	Pectoral girdle	Pelvic girdle
(i)	It lies on the postero-lateral aspect of the upper region of the thorax.	It is located in the lower part of the trunk.
(ii)	It consists of 2 dissimilar bones: scapula and clavicle.	It consists of 2 similar bones, innominate.
(iii)	Scapula and clavicle are not further divided into any type of bone.	Each innominate bone consists of three bones : ilium, ischium and pubis.
(iv)	It provides articulation to the arm bones.	It provides articulation to the bones of the leg.
(v)	It has at its lateral angle a shallow concavity, the glenoid cavity, for articulation of the head of the humerus.	It has at the middle of its lateral surface a deep, cup-shaped hollow, acetabulum.

6. Match Column I with Column II:

Column I	Column II
(a) Smooth muscle	(i) Myoglobin
(b) Tropomyosin	(ii) Thin filament
(c) Red muscle	(iii) Sutures
(d) Skull	(iv) Involuntary

Solution. (a) – (iv), (b)-(ii), (c)-(i), (d)-(iii)

7. What are the different types of movements exhibited by the cells of human body?

Solution: The cells of human body show three types of movements: amoeboid, ciliary and muscular.

Amoeboid movements: These are found in leucocytes of blood and phagocytes of certain body organs. In such cells, movements are brought with the help of temporary finger-like cytoplasmic projections, called pseudopodia or false feet. So

it is also called pseudopodial movement. These pseudopodia are formed by flow of cytoplasm, called cyclosis (simplest form of movement), and cytoskeletal structures like microfilaments.
Ciliary movements: Large number of our internal tubular organs are lined by ciliated epithelium. For instance, the cilia of the cells lining the trachea, oviducts and vasa efferentia propel dust particles, eggs and sperms respectively by their coordinated movements in specific directions in these organs. Muscular movements: These are brought about by the action of skeleton, joints and muscles. These are of two types: movements of body parts and locomotion.

8. How do you distinguish between a skeletal muscle and a cardiac muscle?
Solution: We can distinguish between a skeletal muscle and a cardiac muscle on the basis of the features discussed in the following table:

	Skeletal or striated muscle	Cardiac muscle
(i)	They are present in the limbs, body walls, tongue, pharynx and beginning of oesophagus.	They are present in wall of the heart, pulmonary veins and superior vena cava.
(ii)	Fibres unbranched.	Fibres branched.
(iii)	Multinucleate	Uninucleate
(iv)	Light and dark bands present.	Faint light and dark bands present.
(v)	No oblique bridges and intercalated discs.	Oblique bridges and intercalated discs present.
(vi)	Nerve supply from central nervous system.	Nerve supply from the brain and autonomic nervous system.
(vii)	Very rapid contraction.	Rapid contraction.
(viii)	They soon get fatigued.	They never get fatigued.
(ix)	Voluntary	Involuntary

9. Name the type of joint between the following:
(a) atlas/axis
(b) carpal/metacarpal of thumb
(c) between phalanges
(d) femur/acetabulum
(e) between cranial bones
(f) between pubic bones in the pelvic girdle

Solution: (a) Pivot joint
(b) Saddle joint
(c) Hinge joint
(d) Ball and socket joint
(e) Fibrous joint
(f) Cartilaginous joint

10. Fill in the blank spaces:
(a) All mammals (except a few) have……. cervical vertebra.
(b) The number of phalanges in each limb of human is…….
(c) Thin filament of myofibril contains two 'F' actins and two other proteins namely…….and…….
(d) In a muscle fibre Ca^{++} is stored in …….
(e)…….and…….pairs of ribs are called floating ribs.
(f) The human cranium is made of……. bones.

Solution: (a) 7
(b) 14
(c) tropomyosin, troponin
(d) sarcoplasmic reticulum
(e) 11th and 12th
(f) 8

Neural Control and Coordination Class 5 Notes

The human body has several organs. These organs cannot perform their functions independently. In order to maintain homeostasis for the normal physiology of the human body, functions of these organs/organ systems in our body must be coordinated, so that they can work in proper manner.

Topic 1 Nervous System : An Overview

Coordination is the process through which two or more organs interact and complement the functions of one another. On the other hand, integration is a process, which makes two or more organs to work as a functional unit in harmony.

For instance, when we do exercise, we observe significant increase in the rate of respiration, heart beat, blood flow, sweating, etc., to meet enhanced need of nutrients and energy for increased activities of lungs, heart, muscles and many other body organs, when we stop exercising, we witness that the increased activities of lungs, heart, nerves, kidneys, muscles, etc., gradually return to normal. Thus, during exercise, functions of various organs of the body are coordinated and integrated.

In higher animals (including human), two types of systems have been developed for the control, coordination and integration, i.e., nervous system and endocrine system. The nervous system provides an organised network of point to point connections for quick neural coordination. The endocrine system provides chemical integration through hormones.

Neural System
The neural system is the control system of the body which consists of highly specialized cells called neurons. The sensory neurons detect and receive information from different sense organs (receptors) in the form of stimuli and transmit the stimuli to the Central Neural System (CNS) through sensory nerve fibers. In CNS the processing of information is done and a conclusion is drawn.

The conclusion is sent to different organs (effectors) through motor nerves. These effectors then show the response accordingly.

The neural or nervous system is present in most of the multicellular animals. Its complexity increases from lower to higher animals.
Invertebrates have relatively simpler nervous system than the vertebrates.

Human Neural System
The whole nervous system of human being is derived from embryonic ectoderm.
The human neural system is divided into two parts
(i) the Central Neural System (CNS)
(ii) the Peripheral Neural System (PNS)
The CNS includes the brain and the spinal cord and is the site of information processing and control.
The PNS comprises of all the nerves of the body associated with the CNS (brain and spinal cord).

The nerve fibres of the PNS are of two types
(a) Afferent Fibres They transmit impulses from tissues/organs to the CNS.
(b) Efferent Fibres They transmit regulatory impulses from the CNS to the concerned peripheral tissues/organs.
The PNS is divided into two divisions i.e., somatic neural system and autonomic neural system.

The somatic neural system relays impulses from the CNS to skeletal muscles while, the autonomic neural system transmits impulses from the CNS to the involuntary organs and smooth muscles of the body.
The autonomic neural system is further classified into sympathetic neural system and parasympathetic neural system.

Neuron (Structural and Functional Unit of Neural System)
Neurons are the longest cells in the body. Human neural system has about 100 billion neurons. Majority of the neurons occur in the brain. Fully formed neurons never divide and remain in interphase throughout life.

A neuron is a microscopic structure composed of three major parts
1. Cell Body (Cyton or Soma)
Like a typical cell it consists of cytoplasm, nucleus and cell membrane. The cytoplasm has typical cell organelles like mitochondria, Golgi apparatus, rough endoplasmic reticulum, ribosomes, lysosomes, certain granular bodies, neurofibrils,

neurotubules and Nissl's granules.
Presence of neurofibrils and Nissl's granules is the characteristic to all neurons.
Neurofibrils play a role in the transmission of impulses.

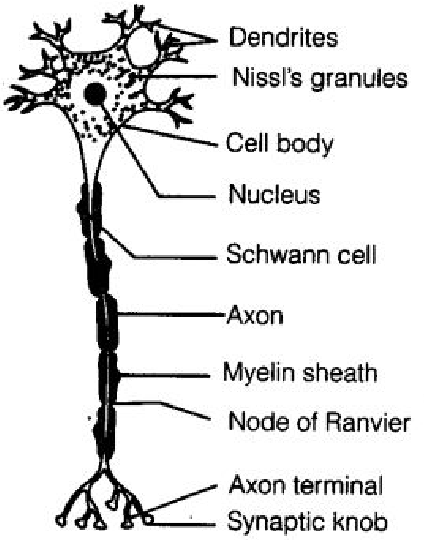


Fig. 21.1 Structure of a neuron

2. Dendrites (Dendrons)

Dendrites are usually shorter, tapering and much branched processes that project out of the cell body. They also contain Nissl's granules and may be one to several in number.
They conduct nerve impulses towards the cell body and are called afferent processes (receiving processes).

3. Axon

Axon is a single, usually very long process of uniform thickness. The part of cyton from where the axon arises is called axon hillock (most sensitive part of neuron).

The axon contains neurofibrils and neurotubules but does not have Nissl's granules, cell organelles and granular bodies. The axon ends (distal end) in a group of branches, the terminal arborization (axon terminals).
When terminal arborisations of the axon meet the dendrites of another neuron to form a synapse, each branch terminates as a bulb-like structure called synaptic knobs, which possess mitochondria and secretory vesicles (containing chemicals called neurotransmitters). The axons transmit nerve impulses away from the cell body to a synapse or to a neuromuscular junction.

There are two types of axon
a. Myelinated
In myelinated nerve fibres Schwann cells form myelin sheath around the axon. The gaps between two adjacent myelin sheaths are called nodes of Ranvier. Myelinated nerve fibres are found in cranial and spinal nerves.

b. Non-myelinated
In non-myelinated nerve fibres Schwann cell does not form myelin sheath around the axon and are without nodes of Ranvier. They are commonly found in autonomous and somatic neural systems.

Types of Neurons on the Basis of Structure
Based on the number of axon and dendrites, the neurons are divided into three types
(i) Multipolar neurons These neurons have several dendrites and an axon. They are found in cerebral cortex.
(ii) Bipolar neurons These neurons have one dendrite and one axon. They are present in the retina of eye.
(iii) Unipolar neurons These neurons have cell body with one axon only. These are found usually in the embryonic stage.

Main Properties of Neural Tissue

The neural tissue has two outsandingproperties
(a) Excitability It is the ability of nerve cells to generate an electrical impulse in response to a stimulus by altering the normal potential difference across their plasma membrane.
(b) Conductivity It is the ability of nerve cells to rapidly transmit the electrical impulse as a wave from the site of its origin along their length in a particular direction.

Functions of Neural System
The nervous system serves the following important functions
(i) Control and coordination Nervous system controls and coordinates the working of all parts of the body so that it functions as an integrated unit. This is achieved by three overlapping processes, i.e., sensory input, integration and motor output.

(ii) Memory Nervous system stores the impressions of previous stimuli and retrieves (recalls) these impressions in future. These impressions are referred to as the experiences or memory.

(iii) Homeostasis Nervous system helps in the maintenance of the body's internal environment, i.e., homeostasis.

Generation and Conduction of Nerve Impulse

Nerve impulse is a wave of bioelectric/electrochemical disturbance that passes along a neuron during conduction of an excitation.

Impulse conduction depends upon

(i) Permeability of axon membrane (axolemma).

(ii) Osmotic equilibrium (electrical equivalence) between the axoplasm and Extracellular Fluid (ECF) present outside the axon.

The generation of a nerve impulse is the temporary reversal of the resting potential in the neuron.

It occurs in following three steps

Polarisation (Resting Potential)

In a resting nerve fibre (a nerve fibre that is not conducting an impulse), the axoplasm (neuroplasm of axon) inside the axon contains high concentration of K^+ and negatively charged proteins and low concentration of Na^+.

(i) In contrast, the fluid outside axon contains a low concentration of K^+ and a high concentration of Na^+ and thus form a concentration gradient.

(ii) These ionic gradients across the resting membrane are maintained by the active transport of ions by the sodium-potassium pump, which transports $3Na^+$ out wards and $2K^+$ inwards (into the cell).

(iii) As a result, the outer surface of the axonal membrane possesses a positive charge, while its inner surface becomes negatively charged and therefore, is polarised.

(iv) The electrical potential difference across the resting plasma membrane is called as the resting potential. The state of the resting membrane is called polarised state.

Depolarisation (Action Potential)
When a stimulus of adequate strength (threshold stimulus) is applied to a polarised membrane, the permeability of the membrane to Na^+ ions is greatly increased at the point of stimulation (site A).
(i) This leads to a rapid influx of Na^+ followed by the reversal of the polarity at that site, i.e., the outer surface of the membrane becomes negatively charged and the inner side becomes positively charged. The polarity of the membrane at the site A is thus, reversed and said to be depolarised.

(ii) The electrical potential difference across the plasma membrane at the site A is called the action potential, another name of nerve impulse.

(iii) At adjacent sites, e.g., site B, the membrane (axon) has positive charge (still polarised) on the outer surface and a negative charge on its inner surface.

(iv) The stimulated negatively charged point on the outside of the membrane sends out an electrical current to the positive point next to it. As a result, a current flows on the outer surface from site B to site A, while on the inner surface current flows from site A to site B.

This process (reversal) repeats itself over and over again and a nerve impulse is conducted through the length of the neuron.

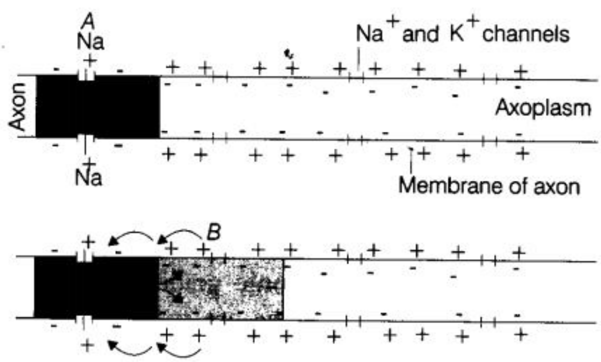


Fig. 21.2 Diagrammatic representation of impulse conduction through an axon

Re-polarization
(i) The rise in the stimulus-induced permeability to Na^+ is extremely short-lived. It is quickly followed by a rise in permeability to K^+.
(ii) Within a fraction of a second, Na^+ influx stops and K^+outflow begins until the original resting state of ionic concentration is achieved. Thus, resting potential is restored at the site of excitation, which is called repolarisation of the membrane.

This makes the fibre once more responsive to further stimulation.
(iii) In fact until repolarisation occurs neuron cannot conduct another impulse. The time taken for this restoration is called refractory period.

Note:

- When an impulse travels along a myelinated neuron, depolarisation occurs only at the nodes of Ranvier. It leaps over the myelin sheath from one node to the next. This process, is called saltatory conduction.
- This process accounts for the greater speed of an impulse travelling along a myelinated neuron than along a non-myelinated one. It is upto 50 times faster than the non-myelinated nerve fibre.
- A nerve impulses is transmitted from one neuron to another through junctions called synapses. It is formed by the membranes of a pre-synaptic neuron and a post-synaptic neuron.

There are mainly two types of synapses
Electrical Synapses
(i) The membranes of pre and post-synaptic neurons are in very close proximity (i.e., in continuity). The continuity is provided by the gap junction (small protein tubular structures) between the two neurons.

(ii) In electrical synapse, there is minimal synaptic delay because of the direct flow of electrical current from one neuron into the other across these synapses.
Thus, impulse transmission across an electrical synapses is always faster than that across a chemical synapse. In such synapses, transmission of impulse is very similar to impulse conduction along a single axon.

(iii) Electrical synapses are rarely found in our system. It is found in cardiac muscle fibres, smooth muscle fibres of intestine and the epithelial cells of lens.

Chemical Synapses
The membranes of pre and post-synaptic neurons are separated by a fluid-filled space called synaptic cleft.
A brief description of the mechanism of synaptic transmission is given below
(i) When an impulse (action potential) arrives at a pre-synaptic knob, calcium ions from the synaptic cleft enter the cytoplasm of the pre-synaptic knob.

(ii) The calcium ions cause the movement of the synaptic vesicles to the surface of the knob.
The synaptic vesicles are fused with the pre-synaptic (plasma membrane and get ruptured (exocytosis) to discharge their contents (neurotransmitter) into the synaptic cleft.

(iii) The neurotransmitter of the synaptic cleft binds with specific protein receptor molecules, present on the post-synaptic membrane.

(iv) This binding action changes the membrane potential of the post-synaptic membrane, opening channels in the membrane and sodium ions to enter the cell. This causes the depolarisation and generation of action potential in the post-synaptic membrane. Thus, the impulse is transferred to the next neuron.

(v) The new potential developed may be either excitatory or inhibitory.

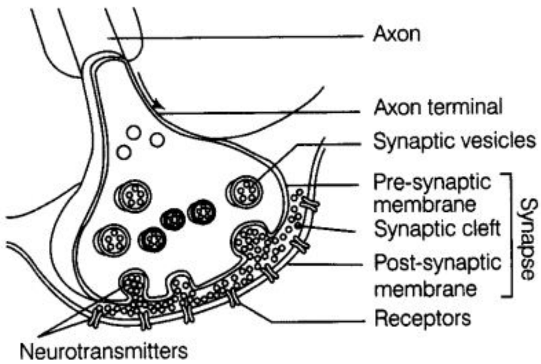


Fig. 21.3 Axon terminal and synapse

Topic 2 Human Nervous System

The human neural system can be categorised to
(a) Central Nervous System (CNS)
(b) Peripheral Nervous System (PNS)

Central Nervous System (CNS)
It is the integrating and command centre of the nervous system which consists of the brain and spinal cord (as discussed earlier).
Brain
The brain is the central information processing organ of our body and acts as the 'command and control system'.

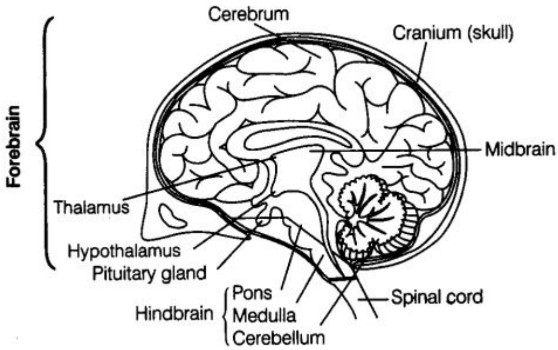


Fig. 21.4 Structure of a brain

It controls the following activities

(i) The voluntary movements and balance of the body.
(ii) Functioning of vital involuntary organs, e.g., Lungs, heart, kidneys, etc.
(iii) Thermoregulation, hunger and thirst.
(iv) Circardian (24 hrs) rhythms of our body.
(u) Activities of several endocrine glands and human behaviour.
(vi) It is also the site for processing of vision, hearing, speech, memory, intelligence, emotions and thoughts.

Location

The brain is the anterior most part of the central neural system, which is located in the cranium
(cranial cavity) of the skull.

Protective Coverings of the Brain

It is covered by three membranes or meninges (cranial meninges)
(i) The outermost membrane, the duramater is the tough fibrous membrane adhering close to the inner side of the skull.
(ii) The middle very thin layer called arachnoid membrane (arachnoid mater).
(iii) The innermost membrane, the piamater is thin, very
delicate, which is in contact with the brain tissue.

Note:

The human brain weights from 1200-1400 g. The human neural system has about 100 billion neurons, majority of them occur in the brain.
The human brain is divisible into three parts
(i) Forebrain (ii) Midbrain (iii) Hindbrain

i. The forebrain
It consists of Olfactory lobes The anterior part of the brain is formed by a pair of short club-shaped structures, the olfactory lobes. These are concerned with the sense of smell.
Cerebrum It is the largest and most complex of all the parts of the human brain. A deep cleft divides the cerebrum longitudinally into two halves, which are termed as the left and right cerebral hemispheres connected by a large bundle of myelinated fibres the corpus callosum.

The outer cover of cerebral hemisphere is called cerebral cortex. The cerebral cortex is referred to as the grey matter due to its greyish appearance (as neuron cell bodies are concentrated here).

The cerebral cortex is greatly folded. The upward folds, gyri, alternate with the downward grooves or sulci. Beneath the grey matter there are millions of medullated nerve fibers, which constitute the inner part of the cerebral hemisphere. The large concentration of medullated nerve fibres gives this tissue an opaque white appearance. Hence, it is called the white matter.

Lobes A very deep and a longitudinal fissure, separates the two cerebral hemispheres. Each cerebral hemisphere of the cerebrum is divided into four lobes, i.e., frontal, parietal, temporal and occipital lobes.
In each cerebral hemisphere, there are three types of junctional areas

Sensory areas receive impulses from the receptors and motor areas transmit impulses to the effectors.

Association areas are large regions that are neither clearly sensory nor motor in junction. They interpret the input, store the input and initiate a response in light of similar past experience. Thus, these areas are responsible for complex functions like memory, learning, reasoning and other intersensory associations.
Distction the posterioventral part of forebrain.

Its main parts are as follows
Epithalamus is a thin membrane of non-nervous tissue. It is the posterior segment of the diencephalon.

The cerebrum, wraps around a structure called thalamus, which is a major coordinating center for sensory and motor signalling.

The hypothalamus, that lies at the base of thalamus contains a number of centres, which control body temperature, urge for eating and drinking. It also contains several groups of neurosecretory cells, which secrete hormones called hypothalamic hormones.

The inner parts of cerebral hemispheres and a group of associated deep structures like amygdala, hippocampus, etc., form a complex structure (limbic lobe or limbic system) that are involved in the regulation of sexual behaviour,expression of emotional reactions, e.g„ excitement, pleasure,rage and fear and motivation,

ii. Midbrain

The midbrain is located between the thalamus hypothalamus of the forebrain and pons of the hindbrain. A canal called the cerebral aqueduct passes through, the midbrain.

The dorsal portion of the midbrain mainly consists of two pairs (i.e., four) of rounded swellings (lobes) called corpora quadrigemina.

iii. Hindbrain

The hindbrain consists of

(a) Pons consists of fibre tracts that interconnect different regions of the brain.

(b) Cerebellum is the second largest part of the human brain (means litde cerebrum). It has very convoluted surface in order to provide the additional space for many more neurons.

(c) Medulla (oblongata) is connected to the spinal cord and contains centres, which control respiration, cardiovascular reflexes and gastric secretions.

Note:

- Midbrain and hindbrain form the brain stem. It is the posterior part of the brain that continues with the spinal cord.
- Out of the twelve pairs of cranial nerves (in higher vertebrates), ten pairs come from the brain stem.

Spinal Cord

(i) It forms the posterior part of the CNS, running mid-dorsally in the neural canal of the vertebral column. In an adult, the spinal cord is about 42-45 cm long. Its

diameter varies at different levels.
(ii) The spinal cord is formed of two types of nervous tissue, i.e., grey matter and white matter.
(iii) The grey matter is surrounded by white matter, which consists of groups of myelinated axons.
(iv) The spinal nerve tracts are divisible into two, ascending (conducting sensory impulses towards brain) and descending (conducting motor impulses from brain).
(v) Spinal cord conducts impulses to and from the brain and controls most of the reflex activities and provides a means of communication between spinal nerves and the brain.

Reflex Action and Reflex Arc

The entire process of response to a peripheral nervous stimulation, that occurs involuntarily, i.e., without conscious effort or thought and requires the involvement of a part of the central nervous system is called a reflex action. The nervous pathway taken by nerve impulses in a reflex action is called reflex arc.

Types of Reflexes
Reflexes are categorised into two
(i) Unconditioned (inborn reflexes and transmitted through heredity) breast feeding and swallowing.
(ii) Conditioned (acquired after birth, i.e., adopted during the course of life time.) e.g., Withdrawl of a body part (like limb) which comes in contact with objects that are extremly hot, cold, pointed or animals that are scary or poisonous.

Mechanism of Reflex Action
(i) The reflex pathway comprises atleast, one afferent (receptor) neuron and one efferent (effector) neuron arranged in a series.
(ii) The afferent neuron receives signal from a sensory organ and transmits the impulse via a dorsal nerve root into the CNS (at the level of spinal cord).

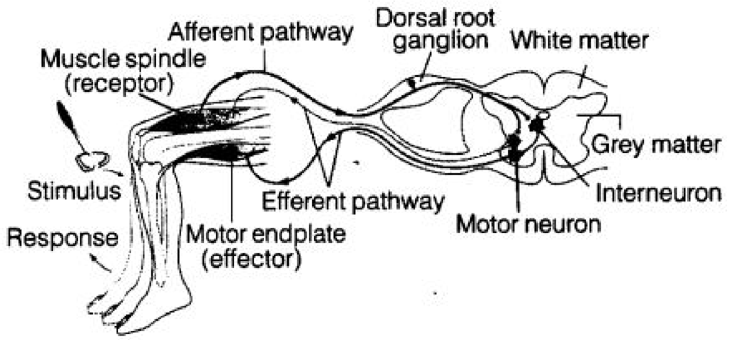


Fig. 21.5 Diagrammatic representation of a reflex action

(iii) The efferent neuron then carries signals from CNS to the effector. The stimulus and response in this way forms a reflex arc, e.g., Knee jerk reflex as shown above in the diagram.

Peripheral Nervous System (PNS)

The peripheral nervous system consists of

1. Somatic Neural System (SNS)
2. Autonomic Neural System (SNS)

1. Somatic Neural System

The somatic neural system contains nerves which relay impulses from CNS to skeletal muscles. These can be further categorised into cranial (from brain) and spinal nerves on the basis of their origin.

i.Cranial Nerves

These nerves emerge specifically from the forebrain and brain stem.

Note:

- Trochlear is smallest and thinnest nerve and possess difficulty in surgical operations.
- Trigeminal is also called dentist nerve. It is the largest cranial nerve. At its origin it is associated with 'Gasserian Ganglion'.
- Facial nerve is associated with geniculate ganglion at its origin.

  Their functions in comparative manner in a nut shell are given below

ii. Spinal Nerves

All spinal nerves are mixed, having sensory and motor fibres in approximately equal numbers. In humans, 31 pairs of spinal nerves are present as Cervical (8 pairs), Thoracic (12 pairs), Lumber (5 pairs), Sacral (5 pairs), Coccygeal (1 pair).

Note:

There are 10 pairs of cranial nerves in fishes and amphibians and 12 pairs in rest of the higher chordates.

There are 10 pairs of spinal nerves found in fishes and amphibians and 31 pairs in humans.

Based on their functions, the nerve fibres of PNS are divided into two groups, i.e., afferent fibres and efferent fibres.

The afferent nerve fibres transmit sensory impulses from tissues/organs to the CNS and form the sensory or afferent pathway. The efferent nerve fibres transmit motor impulses from CNS to the concerned tissues/organs and form the motor or efferent pathways.

2. The Autonomic Neural System (ANS)

The autonomic neural system consists of the sympathetic and parasympathetic nervous system. The former is called thoraco-lumber outflow and the latter is called craniosacral outflow depending upon their origin.

Functions of Sympathetic Nervous System	Functions of Parasympathetic Nervous System
Vasoconstriction in general and vasodialation (brain, heart, lungs and skeletal muscles)	Vasodialation of coronary vessel
Dialates pupil	Constricts pupil
Increases lacrimal glands secretion	Inhibits lacrimal glands secretion
Inhibits salivary glands + digestive glands	Stimulates
Accelerates heart beat	Retards
Dialates trachea, bronchi and lungs	Constricts
Inhibits gut peristalsis	Stimulates
Contracts anal sphincter	Relaxes and sphincter
Relaxes urinary bladder	Contracts and relaxes
Increases adrenal secretion	Inhibit
Blood sugar increases (glucagon)	Blood suger inhibits (insulin)
Semen ejaculation increases	Increases external genitalia and sex
Increases sweet secretion	Inhibits
Arrection pilli contraction	Relaxes

Topic 3 Sensory Reception and Processing

The sensory organs (receptors) enable us to detect all types of changes in the environment and send appropriate signals to the CNS, where all the inputs are processed and analysed. Signals are then sent to different centres of the brain.

The most complex sensory receptors consist of numerous sense cells, sensory neurons and associated accessory structures. For example, eye (sensory organ for vision) and the ear (sensory organ for hearing).

Eye
The organ of sight are a pair of eyes in human.

Position
The eyes are situated in the deep protective bony cavities, called the orbits or eye sockets of the skull.

Parts of an Eye
The adult human eye ball is nearly spherical in structure. It consists of tissues present in three concentric layers
(i) Outermost fibrous layer composed of sclera and cornea.
(ii) Middle layer consists of choroid, ciliary body and iris.
(iii) Innermost layer consists df retina.

Outermost Layer
(i) Sclera is an opaque outermost covering, composed of dense connective tissue that maintains the shape of the eyeball and protects all the inner layers of the eye.
(ii) Cornea is a thin transparent, front part of sclera, which lacks blood vessels but is rich in nerve endings.

Middle Layer
(i) Choroid is a pigmented layer (bluish) present beneath the sclera. It contains numerous blood vessels and nourishes the retina. The choroid layer is thin over the posterior two-thirds of the eye ball, but it becomes, thick in the anterior part to form the ciliary body.

(ii) The eye ball contains a transparent crystalline structure called lens. Ciliary body holds the lens in position, stretching and relaxation of ciliary body changes the focal length of the lens for accomodation.

(iii) Iris forms a pigmented circle of muscular diaphragm attached to the ciliary body in front of the lens. Its pigment gives eye its colour.
The movement of muscle fibres of iris controls the size (diameter) of pupil.

(iv) Pupil is the aperture surrounded by the iris. It contains two types of smooth muscles, circular muscles (sphincters) and radial muscles (dilators) of ectodermal origin.

(v) Sympathetic stimulation causes the radial muscles to contract and the pupil to dilate or get larger. Parasympathetic stimulation causes the circular muscles to contract and the pupil to constrict.

Inner Layer
The inner layer is the retina and it contains three layers of cells from inside to outside, i.e., ganglion cells, bipolar cells and photoreceptor cells.

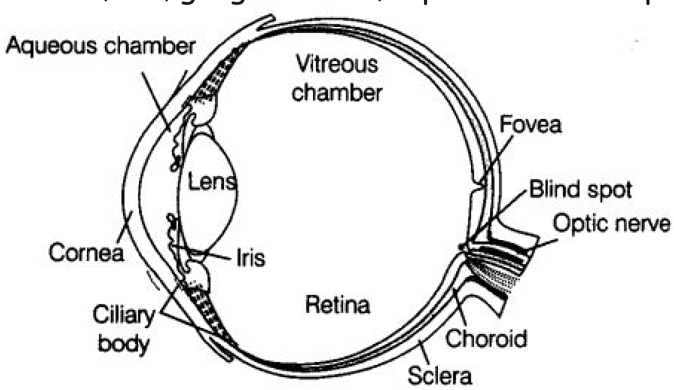


Fig. 21.6 Diagram showing different parts of an eye

The photoreceptors or visual cells are of two types, i.e., rods (rod cells) and cones (cone cells). Both of these cells contain light sensitive proteins called the photopigments.

The twilight (scotopic) vision is the function of the rods. These cells contain a purplish-red protein called the rhodopsin (visual purple), which contains a derivative of vitamin-A.

The daylight (photopic) vision and colour vision are functions of cones. There are three types of cones, which possesses characteristic photopigments that respond to red, green and blue lights.

The sensation of different colours are produced by various combinations of these cones and their photopigments. In case of equal stimulation of these cones, a sensation of white light is produced.

Optic Nerves

The optic nerves are connected with the brain. These nerves leave the eye and the retinal blood vessels enter it at a point medial to and slightly above the posterior pole of the eye-ball. Photoreceptor cells (rods and cones) are not present in that region and hence, it is called blind spot, as no image is formed at this spot.

Macula Lutea and Fovea Centralis

At the posterior pole of the eye lateral to the blind spot, there is a small oval, yellowish area of the retina called the macula lutea or yellow spot, which has at its middle a shallow depression, the fovea centralis (fovea).
The fovea is a thinned out portion of the retina where only the cones are densly packed. It is the point where the visual acuity (resolution) is the greatest.

Contents of the Eye

(i) Aqueous Humour The space between the cornea and lens is called the aqueous chamber, which contains a thin watery fluid called aqueous humour.
(ii) Vitreous Humour The space between the lens and retina is called the vitreous chamber, which is filled with a transparent get called the vitreous humour.

Mechanism of Vision

In human eyes, the vision is called binocular vision (i.e., both the eyes can be focused on a common object).
(i) Retina receives light rays (in visible wavelength) through the cornea and lens generate impulses in rods and cones.
(ii) The photosensitive compounds (photopigments) in the human eye are composed of opsin (a protein) and retinal (an aldehyde of vitamin-A).
(iii) The received light induces dissociation of the retinal from opsin resulting in changes in the structures of the opsin. This causes the changes in the permeability of membrane.

As a result, the potential differences are generated in the photoreceptor cells. This produces a signal that generates action potential in the ganglion cells through the bipolar cells.
(iv) These impulses (action potentials) are transmitted by the optic nerves to the visual cortex of the brain.
(v) In brain, neural impulses are analysed and the image formed on the retina is recognised (based on earlier
memory and experience).

Common Diseases
(i) Cataract This is a eye disease generally occur in older people (above 60 years). Lens becomes opaque due to disease or ageing. It leads to blindness. It can be corrected by wearing suitable glasses or by replacing the defective lens with a normal lens from a donor.

(ii) Myopia (near or short sightedness) It occurs due to convexity of lens or longer eye ball, which results in an image of distant objects being formed in front of the retina, and can be corrected by wearing spectables or concave lenses.

(iii) Hypermetropia (far or long sightedness.) The image of nearer object becomes blurred. It is due to image being formed beyond the retina due to eye ball being short or lens being flattened. It can be corrected by wearing convex or convergent lenses.

(iv) Presbiopia It generally occurs after 40 years. The loss of elasticity in the eye lens occurs so that near objects (written or printed words) are not correcdy visible. It can be correct'd by convex/bifocal lenses.

Ear
Ears are a pair of statiocoustic organs meant for both sensory functions, i.e., hearing and maintenance of body balance.

Position
The ears are located on the sides of the head.
In most mammals, the ear is a flap of tissue also called pinna. It is a part of auditory system.

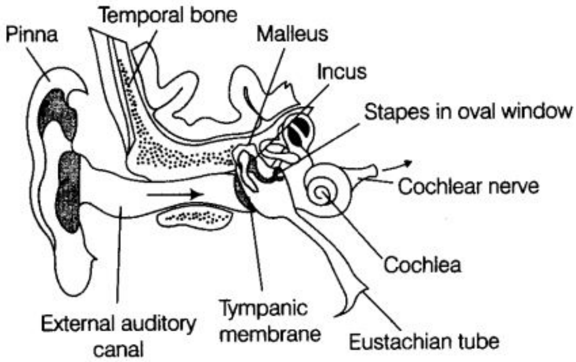


Fig. 21.7 Diagrammatic view of ear

The mammalian ear can be anatomically divided into three major sections

1. External Ear

The external ear consists of pinna and the auditory canal (external auditory meatus), which collect sound waves and channel them to tympanic membrane (ear drum) separating the outer ear from the middle ear.
The auditory canal leads inwards and extends upto the tympanic membrane (the ear drum).

There are very fine hairs and wax-secreting sebaceous glands in the skin of the pinna and the meatus. The tympanic membrane is composed of connective tissues covered with skin outside and with mucus membrane inside.

2. Middle Ear

The middle ear contains three ossicles called malleus (hammer), incus (anvil) and stapes (stirr-up), which are attached to one another in a chain-like fashion.
The malleus is attached to the tympanic membrane and the stapes is attached to the oval window (a membrane beneath the stapes) of cochlea.

These ossicles increase the efficiency of transmission of sound waves to the inner ear.

The middle ear also opens into the Eustachian tube, which connects with the pharynx and maintains the pressure on either sides of the ear drum. It also enables you to 'pop' your ears when you change altitude.

3. Inner Ear

The inner ear consist of a labyrinth of fluid-filled chambers within the temporal bone of the skull. The labyrinth consists of two parts the bony and membranous labyrinths. The bony labyrinth is a series of channels. Inside the channels, membranous labyrinth lies, which is surrounded by a fluid called perilymph.

The membranous labyrinth is filled with a fluid called endolymph. The coiled portion of the labyrinth is called cochlea.
The membranes constituting cochlea (the Reissner's and basilar), divide the bony labyrinth into two large canals, i.e., an upper vestibular canal (scala vestibuli) and a lower tympanic canal (scala tympani).

These (both) canals are separated by a small cochlear duct called scala media. The vestibular and tympanic canals contain and the cochlear duct is filled with endolymph.

At the base of the cochlea, the scala vestibuli ends at the oval window while, the scala tympani terminates at the round window, which opens to the middle ear.

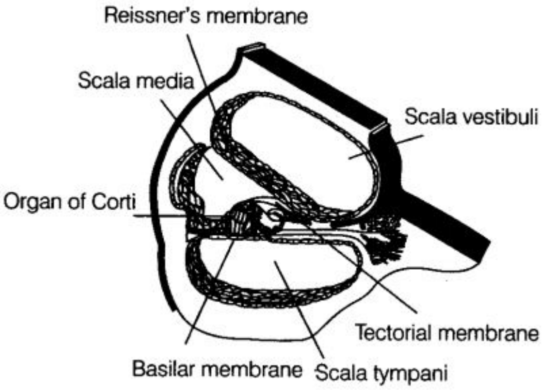


Fig. 21.8 Diagrammatic representation of the sectional view of cochlea

Organ of Corti

The floor of the cochlear duct, the basilar membrane bears the organ of Corti. It contains the mechanoreceptors of the ear. The hair cells are present in rows on the internal side of the organ of Corti, that act as auditory receptors. The basal end of the hair cell is in close contact with the afferent nerve fibres.

A large number of processes called stereo cilia are projected from the apical part of each hair cell. Above the rows of hair cells is a thin elastic membrane called tectorial membrane.

Vestibular Apparatus

(i) The inner ear also contains a complex system called vestibular apparatus (located above the cochlea). It is composed of three semicircular canals and the otolith organ consisting of the saccule and utricle.

(ii) Each semicircular canal lies in a different plane at right angles to each other. The membranous canals are suspended in the perilymph of the bony canals. The base of canals is swollen and is called ampulla, which contains a projecting ridge called crista ampullaris, which has hair cells.

(iii) The saccule and utricle contain a projecting ridge called macula. The crista and macula are the specific receptors of the vestibular apparatus responsible for the maintenance of balance of the body and posture.

Mechanisms of Hearing

(i) Sound waves from the environment are received by the external ear and it directs them to the ear drum.
(ii) The ear drum vibrates due to sound waves and the vibrations are send to oval window through the ear ossicles (malleus, incus and stapes).
(iii) The vibrations are passed through the oval window on to the fluid of the cochlea, where they generate waves in the lymph.
(iv) The waves in the lymph induce a ripple in the basilar membrane.

(v) These movements of the basilar membrane bend the hair cells, pressing them against the tectorial membrane. Due to this, the nerve impulses are generated in the associated afferent neurons. These impulses are transmitted by the afferent fibres via auditory nerves to the auditory cortex of the brain, where the impulses are analysed and the sound is recognised.

Common Diseases

(i) Meniere's Syndrome It is a hearing loss due to pathological distension of membranous labyrinth.
(ii) Eustachitis It occurs due to inflammation of Eustachian tube.
(iii) Tympanitis It is due to inflammation of ear drum.
(iv) Otalgia Pain occurs in ear.
(v) Otitis media Acute infection in middle ear.

MCQ Questions for Class 5 Biology

Question 1.
Which one of the followings is the function of parasympathetic nervous system?
(a) Stimulates oil and sweat glands in the skin
(b) Pupil constriction
(c) Acceleration of heart beat
(d) Contraction of hair muscles

Answer
Answer: (b) Pupil constriction
Question 2.
During resting state, fluid outside axon contains
(a) low concentration of K^+
(b) low concentration of Na^+
(c) low concentration of Cl^-
(d) high concentration of Cl^-

Answer
Answer: (a) low concentration of K^+
Explanation:
During resting state (when neuron is not conducting any impulse), axoplasm inside the axon contains high concentration of K^+
The fluid outside axon contains low concentration of K^+.

Question 3.
The basic cyclic pattern of inspiration and expiration are established by a respiratory center within the ______.
(a) Cerebellum
(b) Medulla oblongata
(c) Cerebral cortex
(d) Thalamus

Answer
Answer: (b) Medulla oblongata

Question 4.
The cutaneous plexus and the papillary plexus consist of
(a) Specialized cells for cutaneous sensations
(b) A network of arteries to provide dermal supply
(c) A network of nerves to provide dermal sensation
(d) Gland cells that release cutaneous secretions

Answer
Answer: (c) A network of nerves to provide dermal sensation

Question 5.
The generation of excitation-contraction coupling involves all the following events except
(a) Generation of end-plate potential
(b) Release of calcium from troponin
(c) Formation of cross-linkages between actin and myosin
(d) Hydrolysis of ATP to ADP

Answer
Answer: (b) Release of calcium from troponin

Question 6.
Which portion of the brain is responsible for various emotions such as pleasure, fear, and happiness?
(a) Thalamus
(b) Reticular formation
(c) Hypothalamus
(d) Limbic system

Answer
Answer: (d) Limbic system

Question 7.
Vestibular apparatus is made up of three semi circular canals. These canals lies at _____ degree angle to each other.
(a) 30
(b) 45

(c) 60
(d) 90

Answer
Answer: (d) 90
Explanation:
Semicircular canals lies at right angle to each other.

Question 8.
At a neuromuscular junction, synaptic vesicles discharge ______.
(a) Acetylcholine
(b) Epinephrine
(c) Adrenaline
(d) None of these

Answer
Answer: (a) Acetylcholine
Question 9.
There are ______ pairs of cranial nerves arising from the brain.
(a) 8
(b) 12
(c) 18
(d) 25

Answer
Answer: (b) 12
Question 10.
When a neuron is in resting state i.e. not conducting any impulse, the axonal membrane is
(a) Comparatively more permeable to K+ ions and nearly impermeable to Na+ ions
(b) Comparatively more permeable to Na+ ions and nearly impermeable to K+ ions
(c) Equally permeable to both Na+ and K+ ions
(d) Impermeable to both Na+ and K+ ions

Answer
Answer: (a) Comparatively more permeable to K+ ions and nearly impermeable to Na+ ions

Question 11.
Which one of the following is the correct statement regarding the particular psychotropic drug specified?
(a) Barbiturates cause relaxation and temporary euphoria
(b) Hashish causes after thought perceptions and hallucinations
(c) Opium stimulates nervous system and causes hallucinations
(d) Morphine leads to delusions and disturbed emotions

Answer
Answer: (b) Hashish causes after thought perceptions and hallucinations

Question 12.
The function of vagus nerve innervating the heart is to
(a) Initiate the heart beat
(b) Reduce the heart beat
(c) Accelerate the heart beat
(d) Maintain constant heart beat

Answer
Answer: (b) Reduce the heart beat

Question 13.
Which of the following nerves is the largest of all the cranial nerves?
(a) Abducens nerve
(b) Oculomotor nerve
(c) Olfactory nerve
(d) Trigeminal nerve

Answer
Answer: (d) Trigeminal nerve

Question 14.
Which of the following is not related to the autonomic nervous system?
(a) Peristalsis
(b) Digestion
(c) Excretion
(d) Memory and learning

Answer
Answer: (d) Memory and learning

Question 15.
Functions of smooth muscles, cardiac muscles, organs, and glands are regulated by _______ system.
(a) Parasympathetic
(b) Sympathetic
(c) Central nervous
(d) Autonomic

Answer
Answer: (d) Autonomic

Question 16.
Which neuroglia cells produce a fatty insulating material called myelin?
(a) Satellite cells
(b) Schwann cells
(c) Both (A) and (B)
(d) Neither (A) nor (B)

Answer
Answer: (b) Schwann cells

Question 17.
Which layer is in contact with brain tissues?
(a) Piamater
(b) Arachnoid
(c) Duramater
(d) Piamater and Arachnoid

Answer
Answer: (a) Piamater
Explanation:
Brain is covered by cranial meninges.
1) Duramater (outer)
2) Arachnoid (middle)
3) Piamater (inner)- in contact with brain tissues)

Question 18.
The thin and convoluted outer layer of gray matter that covers the cerebral hemispheres is
(a) Medulla oblongata
(b) Thalamus
(c) Cerebral cortex
(d) Meninges

Answer
Answer: (c) Cerebral cortex

Question 19.
Find the odd one.
(a) Schwann cells
(b) Nissl s granules
(c) nephrons
(d) synaptic knob

Answer
Answer: (c) nephrons
Explanation:
Schwann cells, Nissl s granules and synaptic knobs are the parts of neurons.

Question 20.
Select the correct statement from the ones given below
(a) Cocaine is given to patients after surgery as it stimulates recovery
(b) Barbiturates when given to criminals make them tell the truth
(c) Morphine is often given to persons who have undergone surgery as a pain killer
(d) Chewing tobacco lowers blood pressure and heart rate

Answer
Answer: (c) Morphine is often given to persons who have undergone surgery as a pain killer

Solutions for Class 11 Biology Chapter 21 Neural Control and Coordination:

Section Name	Topic Name
21	Neural Control and Coordination
21.1	Neural System

TEXTBOOK QUESTIONS FROM SOLVED

1. Briefly describe the structure of the following:
(a) Brain (b) Eye (c) Ear

Solution: (a) Brain: The brain acts as control and command system of the body. It is protected by skull and is covered by three meninges. It is divisible into three main regions: forebrain, midbrain and hindbrain.

(i) Forebrain – It consists of three regions:

(a) Olfactory lobes: These are a pair of very small, solid club-shaped bodies which are widely separated from each
other. They are fully covered by cerebral hemispheres.

(b) Cerebrum – It is the largest and most complex of all the parts of human brain. A deep cleft divides the cerebrum into right and left cerebral hemispheres, connected by myelinated fibres, the corpus callosum.

(c) Diencephalon – It encloses a slit-like cavity, the third ventricle. The thin roof of this cavity is known as the epithalamus, the thick right and left sides as the thalami, and floor as the hypothalamus.

(ii) Midbrain – It is located between thalamus/ hypothalamus of forebrain and pons of hindbrain. Its upper surface has two pairs of rounded protrusious called corpora quadrigemina and two bundles of fibres called crura cerebri.

(iii) Hindbrain – It consists of:

(a) Cerebellum – The second largest part of the human brain is the cerebellum. It consists of two lateral cerebellar hemispheres and central worm-shaped part, the vermis. The cerebellum has its grey matter on the outside, comprising three layers of cells and fibres. It also has Golgi cells, basket cells and granule cells.

(b) Pons varolii – An oval mass, called the pons varolii, lies above the medulla oblongata. It consists mainly of nerve fibres which interconnect different regions of the brain.

(c) Medulla oblongata – It extends from the pons varolii above and is continuous with the spinal cord below. The mid brain, pons varolii and medulla oblongata are collectively called brain stem.

(b) Eye: Eye is a hollow spherical structure composed of three coats:
- Outer fibrous coat
- Middle vascular coat
- Inner nervous coat

(i) Fibrous coat: It is thick and protects the eyeball. It has two distinct regions – sclera and cornea. Sclera covers most of the eye ball. The sclera or white of the eye contains many collagen fibres. Cornea is a transparent portion that forms the anterior one – sixth of the eyeball. The cornea is avascular (i.e., lacks blood supply).
(ii)Vascular coat: It comprises of 3 regions : choroid, iris, ciliary body.
(a) Choroid : It lies adjacent to sclera and contains numerous blood vessels and pigmented cells.
(b) Iris: The iris is a circular muscular diaphragm containing the pigment giving eye its colour. It extends from the ciliary body across the eyeball in front of the lens. It 2. has an opening in the centre called the pupil.
It contains two types of smooth muscles, circular muscles (sphincters) and radial muscles (dilators), of ectodermal origin.
(c) Ciliary body: Behind the peripheral margin of the iris, the vascular coat is thickened to form the ciliary body. It is composed of the ciliary muscles and the ciliary processes.
(iii) Nervous coat: It consists of retina which is neural and sensory layer of an eye ball. It consists of three layers; ganglion cells, bipolar cells and photoreceptor cells (rods and cones).
Lens: It is a transparent, biconvex, elastic structure that bends light waves as they pass through its surface. It is composed of epithelial cells that have large amounts of clear cytoplasm in the form of fibres.
Chambers of eyeball: The lens, suspensory ligament and ciliary body divide the eye into an anterior aqueous chamber and a posterior vitreous chamber which are filled with aqueous humour and vitreous humour respectively.

(c) Ear: There are three portions in an ear:
(i) External ear: It further has 2 regions: pinna and external auditory canal or meatus.
(a) Pinna: The pinna is a projecting elastic cartilage covered with skin. Its most prominent outer ridge is called the helix. The lobule is the soft pliable part at its lower end composed of fibrous and adipose tissue richly supplied with blood capillaries. It is sensitive as well as effective in collecting sound waves.
(b) External auditory canal: It is an S-shaped tube leading inward from the pinna. It is a tubular passage supported by cartilage in its exterior part and by bone in its

interior part.
(ii) Middle ear: It consists of 3 small bones called ear ossicles – malleus, incus and stapes, which are attached to one another and increase efficiency of transmission of sound waves to inner ear.
(iii) Internal ear: It consists of bony and

2. Compare the following:
(a) Central neural system (CNS) and Peripheral neural system (PNS).
(b) Resting potential and action potential.
(c) Choroid and retina.

Solution: (a) CNS: It lies along the mid-dorsal axis of the body. It is a hollow, dorsally placed structure and comprises of brain and spinal cord. It is a centre of information processing and control.
PNS: Nerves arising from the central nervous system constitute the peripheral nervous system. It carries information to and from the CNS. It includes spinal nerves and cranial nerves.
(b) Resting potential: Outside the plasma membrane of a nerve fibre is the extracellular fluid which is positively charged with respect to the cell contents inside the plasma membrane. A resting nerve fibre shows a potential difference between inside and outside of this plasma membrane. This difference in the electrical charges across the plasma membrane is called the 'resting potential'. A membrane with resting potential across it, is said to be electrically polarized. Action potential : Action potential is another name of nerve impulse. The contents inside a cell at the excited state becomes positively charged with respect to extracellular fluid outside it. This change in polarity across the plasma membrane is known as an action potential. The membrane with reversed polarity across it is said to be depolarized.
(c) Choroid: Choroid lies adjacent to the sclera and contains numerous blood vessels that supply nutrients and oxygen to the other tissues especially of retina. It contains abundant pigment cells and is dark brown in colour.
Retina: It is the neural and sensory layer of the eye ball. It is a very delicate coat and lines the whole of the vascular coat. Its external surface is in contact with the choroid and its internal surface with vitreous humour. It contains ganglion cells, bipolar cells and photoreceptor cells. membranous labyrinth. Membranous labyrinth consists of three semicircular ducts, utricle, saccule and cochlea.

3. Explain the following processes:
(a) Polarisation of the membrane of a nerve fibre.

(b) Depolarisation of the membrane of a nerve fibre.
(c) Conduction of a nerve impulse along a nerve fibre.
(d) Transmission of a nerve impulse across a chemical synapse.

Solution: (a) Polarisation of the membrane of a nerve fibre : In the resting (not conducting impulse) nerve fibre the plasma membrane separates two solution of different chemical composition but having approximately the same total number of ions. In the external medium (tissue fluid), sodium ions (Na^+) and Cl^- ions predominate, whereas within the fibre (intracellular fluid) potassium ions (K^+) predominate. The differential flow of the positively charged ions and the inability of the negatively charged organic (protein) ions within the nerve fibre to pass out cause an increasing positive charge on the outside of the membrane and negative charge on the inside of the membrane. This makes the membrane of the resting nerve fibre polarized, extracellular fluid outside being electropositive (positively charged) with respect to the cell contents inside it.

(b) Depolarisation of the membrane of a nerve fibre: During depolarisation, the activation gates of Na channels open, and the K channels remain closed. Na^+ rush into the axon. Entry of sodium ions leads to depolarisation (reversal of polarity) of the nerve membrane, so that the nerve fibre contents become electropositive with respect to the extracellular fluid.

(c) Conduction of a nerve impulse along a nerve fibre: Nervous system transmits information as a series of nerve impulses. A nerve impulse is the movement of an action potential as a wave through a nerve fibre. Action potentials are propagated, that is, self-generated along the axon. The events that set up an action potential at one spot on the nerve fibre also transmit it along the entire length of the nerve fibre. The action potential then moves to the neighbouring region of the nerve fibre till it covers the whole length of the fibre.

(d) Transmission of a nerve impulse across a chemical synapse: At a chemical synapse, the membranes of the pre- and post- synaptic neurons are separated by a fluid- filled space called synaptic cleft. Chemicals called neurotransmitters are involved in the transmission of impulses at these synapses. The axon terminals contain vesicles filled with these neurotransmitters. When an impulse (action potential) arrives at the axon terminal, it stimulates the movement of the synaptic vesicles towards the membrane where they fuse with the plasma membrane and burst to release their neurotransmitters in the synaptic cleft. The released neurotransmitters bind to their specific receptors, present on the post- synaptic membrane. This binding opens ion channels allowing the entry of ions which can generate a new potential in the post-synaptic neuron. The new potential developed may be either excitatory or inhibitory.

4. Draw labelled diagrams of the following:
(a) Neuron (b) Brain
(c) Eye (d) Ear

Solution: (a)

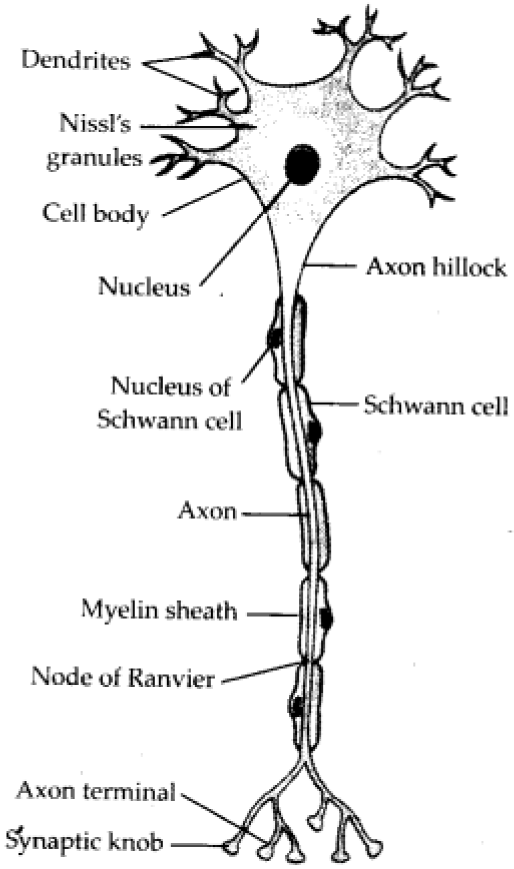


Fig.: Structure of a neuron

(b)

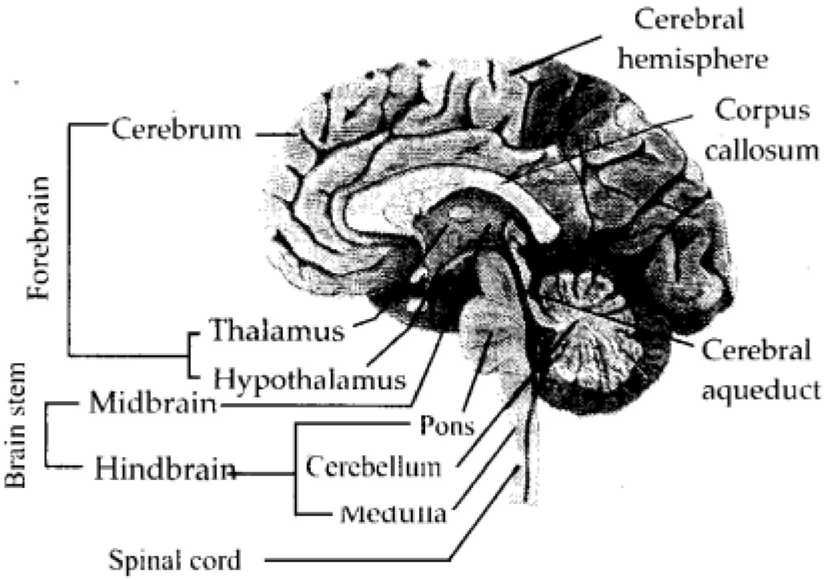


Fig.: Diagram showing sagital section of the human brain

(c)

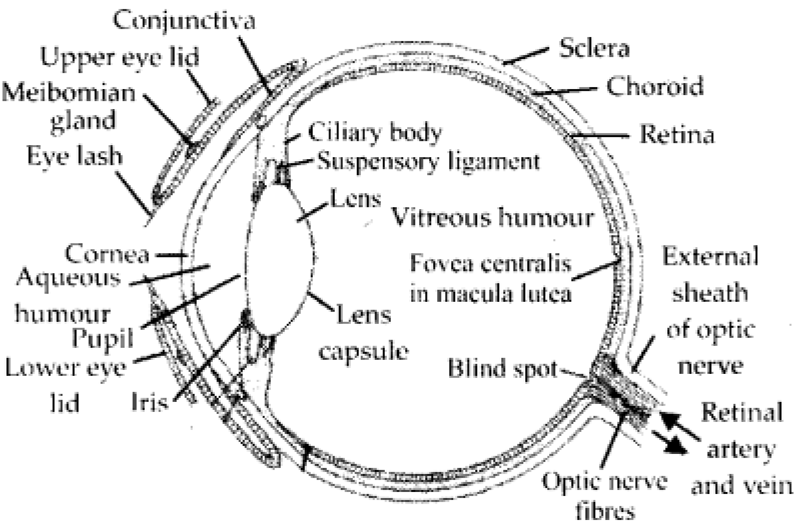


Fig.: V.S. of human eye.

(d)

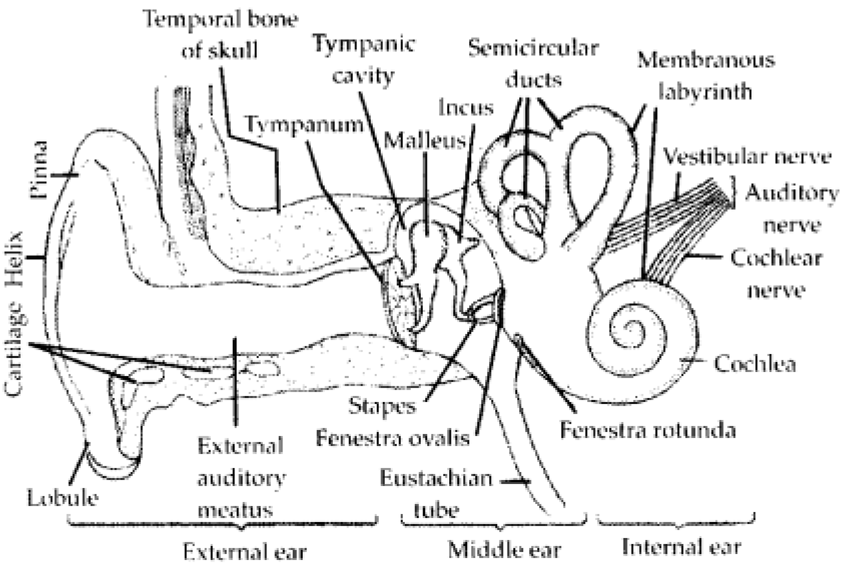


Fig.: The parts of ear.

5. Write short notes on the following:
(a) Neural coordination (b) Forebrain
(c) Midbrain (d) Hindbrain
(e) Retina (f) Ear ossicles
(g) Cochlea (h) Organ of Corti
(i) Synapse

Solution: (a) Neural coordination : When higher animals respond to various stimuli, each response to a specific stimulus generally involves many organs (parts) of their bodies. Therefore, it is necessary that all the concerned organs (parts) of the body should work in a systematic manner to produce the response. The working together of various organs (parts) of the body of multicelullar organism in a proper manner to complement the functions of each other is called coordination. This is achieved by three overlapping processes of nervous system-sensory input, integration and motor output.

(b) Forebrain: It consists of: Olfactory lobes, the paired structures concerned with the sense of smell. Cerebrum which is the largest and most complex of all the parts of the human brain. It is divided by a cleft into left and right cerebral hemispheres which are connected by a large bundle of myelinated fibres the. corpus callosum. The outer cover of cerebral hemisphere is called cerebral cortex. It consists of sensory and motor areas. Hypothalamus region of forebrain contains centres which control body temperature, hunger and also contains group of neurosecretory cells.

(c) Midbrain: The midbrain is located between the thalamus/hypothalamus of the forebrain and pons of the hindbrain. A canal called the cerebral aqueduct passess through the midbrain. The dorsal portion of the midbrain consists mainly of four round swellings (lobes) called corpora quadrigemina. Midbrain and hindbrain form the brain stem.
(d) Hindbrain: The hindbrain comprises pons, cerebellum and medulla. Pons consists of fibre tracts that interconnect different regions of the brain. Cerebellum has very convoluted surface in order to provide the additional space of many more neurons. The medulla of the brain is connected to the spinal cord. The medulla contains centres which control respiration, cardiovascular reflexes and gastric secretions.
(e) Retina: Retina is the inner layer of an eye and it contains three layers of cells- from inside to outside – ganglion cells, bipolar cells and photoreceptor cells. There are two types of photoreceptor cells, namely, rods and cones. These cells contain the light-sensitive proteins called the photopigments. The daylight (photopic) vision and colour vision are functions of cones and the twilight (scotopic) vision is the function of the rods. The rods contain a purplish-red protein called the rhodopsin or visual purple, which contains a derivative of Vitamin A. In the human eye, there are three types of cones which possess their own characteristic photopigments that respond to red, green and blue lights. The sensations of different colours are produced by various combinations of these cones and their photopigments. When these cones are stimulated equally, a sensation of white light is produced.
(f) Ear ossicles : There is a small flexible chain of three small bones called as ear ossicles – the malleus (hammer shaped), the incus (anvil shaped) and the stapes (stirrup shaped) in the middle ear. Malleus is attached to the tympanic membrane on one side and incus on the other side. Incus in turn is connected with the stapes. Malleus is the largest ossicle, however stapes is the smallest ossicle.
(g) Cochlea : It is the main hearing organ which is connected with saccule. It is a spirally coiled tube that resembles a snail shell in appearance. It tapers from a broad base to an almost pointed apex.
(h) Organ of Corti: It is a structure located on the basilar membrane which contains hair cells that act as auditory receptors. The hair cells are present in rows on the internal side of the organ of Corti.
(i) Synapse : It is the junction between the axon of one neuron and the dendrite or cyton of another neuron for transmission of nerve impulse.

6. Give a brief account of
(a) Mechanism of synaptic transmission.

(b) Mechanism of vision.
(c) Mechanism of hearing.
Solution: (a) Mechanism of synaptic transmission: Refer answer 3 (d)
(a) Mechanism of vision: The light rays in visible wavelength focused on the retina through the cornea and lens generate potentials (impulses) in rods and cones. Light induces
dissociation of the retinal from opsin resulting in changes in the structure of the opsin. This causes membrane permeability changes. As a result, potential differences are generated in the photoreceptor cells. This produces a signal that generates action potentials in the ganglion cells through the bipolar cells. These action potentials (impulses) are transmitted by the optic nerves to the visual cortex area of the brain, where the neural impulses are analysed and the image formed on the retina is recognised based on earlier memory and experience.
(b) Mechanism of hearing : The external ear receives sound waves and directs them to the ear drum. The ear drum vibrates in response to the sound waves and these vibrations are transmitted through the ear ossicles (malleus, incus and stapes) to the oval window. The vibrations are passed through the oval window on to the fluid of the cochlea, where they generate waves in the lymphs. The waves in the lymphs induce a ripple in the basilar membrane. These movements of the basilar membrane bend the hair cells, pressing them against the tectorial membrane. As a result, nerve impulses are generated in the associated afferent neurons. These impulses are transmitted by the afferent fibres via auditory nerves to the auditory cortex of the brain, where the impulses are analysed and the sound is recognised.

7. Answer briefly.
(a) How do you perceive the colour of an object?
(b) Which part of our body helps us in maintaining the body balance?
(c) How does the eye regulate the amount of light that falls on the retina?
Solution: (a)In humans, colour vision results from the activity of cone cells, a type of photoreceptor cells. In the human eye, there are three types of cones which possess their own characteristic photopigments that respond to red, green and blue lights. The sensations of different colours are produced by various combinations of these cones and their photopigments. When these cones are stimulated equally, sensation of white light is produced. Yellow light, for instance, stimulates green'and red cones approximately to equal extent, and this is interpreted by the brain as yellow colour.
(b) Ears (cristae and maculae present in internal ears).

(c) The iris contains two sets of smooth muscles – sphincters and dilators. These muscles regulate the amount of light entering the eyeball by varying the size of pupil. Contraction of sphincter muscles makes the pupil smaller in bright light so that less light enters the eye. Contraction of dilator muscles widens the pupil in dim light so that more light goes in eye to fall on retina.

8. Explain the following.
(a) Role of Na^+ in the generation of action potential.
(b) Mechanism of generation of light-induced impulse in the retina.
(c) Mechanism through which a sound produces a nerve impulse in the inner ear.

Solution: (a) The action potential is largely determined by Na^+ ions. The action potential results from the following sequential events
(i) Disturbance caused to the membrane of a nerve fibre by a stimulus results in leakage of Na^+ into the nerve fibre.
(ii) Entry of Na^+ lowers the trans-membrane potential difference.
(iii) Decrease in potential difference makes the membrane more permeable to Na^+ than to K^+ ions so that more Na^+ enter the fibre than K^+ leave it.
(iv) Accumulation of Na^+ in the nerve fibre initiates depolarisation (action potential), making the axonic contents positively charged relative to the extracellular fluid.
(v) With continued addition of Na^+ the potential reaches zero and then plus 40-50 millivolts. This is the peak of action potential.
(vi) Permeability of a depolarised membrane to Na^+ then rapidly drops, there are now as many Na^+ on the inside of the membrane as on the outside.
(b) Refer answer 6 (b)
(c) Refer answer 6 (c)

9. Differentiate between
(a) Myelinated and non-myelinated axons
(b) Dendrites and axons
(c) Rods and cones
(d) Thalamus and Hypothalamus
(e) Cerebrum and Cerebellum

Solution: (a) Differences between myelinated and non-myelinated axons are as follows:

	Myelinated axons	Non-myelinated axons
(i)	AxonshaveSchwann cells, which form myelin sheath.	Myelin sheath is absent.
(ii)	Nodes of Ranvier are present at intervals.	Nodes of Ranvier are absent.
(iii)	Voltage-gated ion channels are concentrated at the nodes; depolarisation occurs only in the nodes.	Voltage-gated . ion channels are spread all over the axon; depolarisation occurs all along the length of nerve fibre.
(iv)	Ion exchange can occur only at the nodes.	Ion exchange occurs all over the surface.
(v)	Action potential does not propagate over internodes, and jumps from node to node.	Action potential propagates all along the axon.
(vi)	Nerve impulse conduction is saltatory.	Nerve impulse conduction is smooth.
(vii)	These carry nerve impulses much faster than non-medullated nerve fibres.	These carry nerve impulses much slower than medullated nerve fibres.
(viii)	These are present in the white matter of brain and spinal cord and in cranial and spinal nerves.	These are present in autonomic nerves.

(b) Axon and dendrites can be differentiated as follows:

	Axon	Dendrites
(i)	Single per neuron.	Usually many per neuron.
(ii)	Arises from a conical projection, the axon hillock, from the discharging end of neuron.	Arises directly from the receiving surface of the neuron.

(iii)	Very long (may be several metres) and of uniform diameter (0.25 – over 10 mm).	Very short (generally under 1.5 mm) and tapering.
(iv)	Branched at the distal end only.	Much branched, practically all along.
(v)	Terminal branches enlarged to form synaptic knobs at the tips.	No knobs at the tips of the branches.
(vi)	Have neurotransmitter-containing vesicles in the knobs.	Do not have such vesicles anywhere.
(vii)	Conduct impulses away from the cyton.	Conduct impulses towards the cyton.

(c) The differences between rods and cones are as follows:

	Rods	Cones
(i)	Outer segment is cylindrical and contains rhodopsin.	Outer segment is conical and contains iodopsin.
(ii)	Inner end has a small knob.	Inner end is branched.
(iii)	Sensitive to dim light, and give "twilight vision."	Sensitive to bright light, and give "daylight" vision.
(iv)	All rod cells are alike, and do not give colour vision.	Cones are of 3 types: blue, green and red, and give colour vision.
(v)	Insufficient rhodopsin results in night blindness.	Insufficient iodopsin results in colour blindness.
(vi)	Rod cells are far more numerous than cone cell .	Cone cells are much fewer than rod cells.

(d) Thalamus and hypothalamus can be differentiated as follows:

	Thalamus	Hypothalamus
(i)	It is present on the right and left sides of the third ventricle.	It is present at the floor of the third ventricle.
(ii)	Each thalamus acts as a relay centre for sensory impulses, except those of smell ; as reflex centre for muscular and glandular activities ; and as a perceiving centre for crude sensation such as extremes of heat, cold, pain, etc.	The hypothalamus contains centres for maintaining homeostasis by regulating body temperature, heart beat, water balance and blood pressure ; controls hunger, thirst, sexual arousal, and feeling of pain, pleasure, anger and fear; and controls the hypophysis.

(e) Cerebrum and cerebellum can be differentiated as follows:

	Cerebrum	Cerebellum
(i)	It is the largest part of the brain, forming four-fifths of its weight.	It is the second largest part of the brain, forming one-eighth of its mass.
(ii)	It is a part of the forebrain.	It is a part of the hindbrain.
(iii)	In consists of 2 cerebral hemispheres each comprising 4 lobes : frontal, occipital, parietal, temporal.	It consists of two cerebellar hemispheres and a median vermis.
(iv)	White matter does not form arbor vitae.	White matter form arbor vitae.
(v)	It initiates voluntary movements, and is a seat of will, intelligence, memory etc.	It maintains posture and equilibrium.

10. Answer the following.
(a) Which part of the ear determines the pitch ofa sound?
(b) Which part of the human brain is the most developed?
(c) Which part of our central neural system acts as a master clock?
Solution: (a) The receptor cells in the organ of Corti (Internal ear).
(b) Cerebrum (cerebral hemispheres).
(c) Pineal gland present in diencephalon of forebrain acts as a master clock, which maintains biological rhythm.

11. The region of the vertebrate eye, where the optic nerve passes out of the retina, is called the
(a) fovea (b) iris
(c) blind spot (d) optic chiasma
Solution: (c) blind spot

12. Distinguish between
(a) Afferent neurons and efferent neurons
(b) Impulse conduction in myelinated nerve fibre and unmyelinated nerve fibre
(c) Aqueous humour and vitreous humour
(d) Blind spot and yellow spot
(e) Cranial nerves and spinal nerves

Solution: (a)

	Afferent neurons	Efferent neurons
(i)	They conduct impulses from the receptors to CNS.	They conduct impulses from CNS to the effectors.
(ii)	They are sensory in nature.	They are motor in nature.

(b) Refer answer 9(a)

(c)

	Aqueous humour	Vitreous humour
(i)	It occurs in aqueous chamber.	It occurs in vitreous chamber.
(ii)	It is a watery fluid.	It is a jelly-like substance.
(iii)	It is secreted by ciliary processes.	It is apparently secreted by retina during development of eye.
(iv)	It is continuously absorbed into blood and replaced.	It is not absorbed or replaced.

(d)

	Blind spot	Yellow spot
(i)	It lies a little away from the yellow spot.	It lies exactly opposite the centre of the cornea.
(ii)	It contains no pigment.	It has a yellow pigment.
(iii)	Optic nerve starts from this spot.	No nerve starts from this spot.
(iv)	It lacks a depression.	It has a shallow depression, the fovea centralis, at its middle.
(v)	It lacks visual receptors and is insensitive to light.	It has visual receptors and is sensitive to light.
(vi)	The eye coats are absent at blind spot.	Eye coats are present at yellow spot.
(vii)	No image is formed at this place.	It is point of greatest visual acuity.

(e)

	Cranial nerves	Spinal nerves
(i)	The nerves that arise from or join the brain are called cerebral or cranial nerves.	Spinal nerves arise from the spinal cord.
(ii)	There are 12 pairs of cranial nerves in humans.	There are 31 pairs of spinal nerves in humans.
(iii)	They are numbered I to XII in Roman numerals.	They are classified into five groups cervical 8 pairs, thoracic 12 pairs, lumbar 5 pairs, sacral 5 pairs and coccygeal 1 pair.

Chemical Coordination and Integration Class 5 Notes Biology

In the previous chapter, you have already learnt that the nervous system in the body, provides point-to-point coordination among the organs. The neural coordination is rapid, but short lived in nature. However, the nerve cells of not reach to each and every cell of the body. So, a special kind of coordination and integration is provided to each cell for continuous cellular functions. This special function is performed by hormones.
Thus, the nervous system and endocrine system are intimately related to each other forming neuroendocrine system together that jointly coordinate together that regulate the physiological functions of the body.

Topic 1 Endocrinology : Major Glands and Their Hormones

Endocrine Glands and Hormones
The endocrine glands are ductless glands, i.e., lack ducts. They pour their secretion into the surrounding blood for transport to the site of action or distandy located target organ. Their secretions are called hormones or internal secretion.

The glands, which have ducts for discharging their secretions onto the body surfaces or into the cavities in the body are called exocrine glands, e.g., Liver, salivary glands, etc.

Hormones
These are non-nutrient chemicals, which are produced in trace amounts and acts as intercellular messengers. These are responsible for regulating the biological processes in the body. The organised endocrine glands also secretes a number of new molecules in addition to the hormones.

Vertebrates have large number of chemicals acting as hormones that provide coordination, while invertebrates possess very simple endocrine systems with few hormones.

Note:

- The first hormone was discovered by William M Bayliss and Earnest H Starling in 1903.
- Endocrinology is the study of endocrine glands and hormones secreted by them.

Human Endocrine System

The endocrine system in humans constitute the endocrine glands and hormone producing diffused tissues/cells located in different parts of our body. In endocrine system, the hormone from one gland may stimulate or inhibit another endocrine gland. These can also vary in structure.

Types of Human Endocrine Glands

The endocrine glands are of following two types in humans

i. Pure Endocrine Glands

It entirely work for the secretion of hormones. They include the hypothalamus, pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus glands and gonads (i.e., testes in males and ovaries in females).

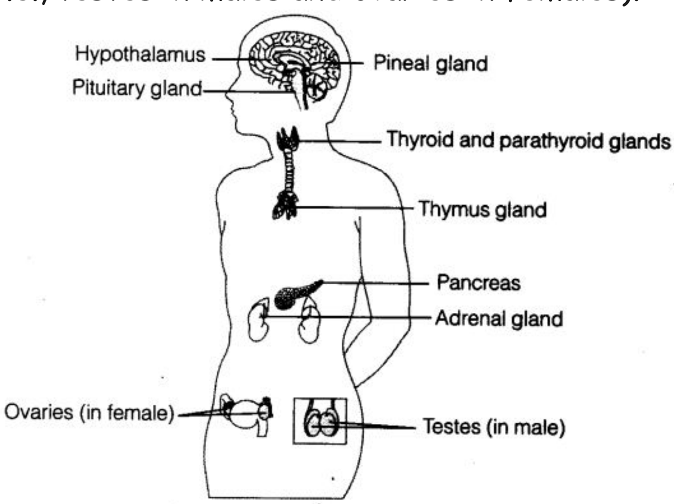


Fig 22.1 Location of different endocrine glands

ii. Partial Endocrine Glands

These are pardy endocrine and partly exocrine in function. They includes kidneys, liver, gastro-intestinal tract, heart, placenta, etc.

Structure and Functions of Major Endocrine Glands

Hypothalamus

In humans, the complete endocrine system works more or less under the influence of hypothalamus.

Location

Hypothalamus is located in the basal part of diencephalon (forebrain) regulates a wide spectrum of functions in the body.

Origin

It develops from the ectoderm of embryo like other parts of brain.
with the anterior lobe of pituitary by hypophysial portal blood vessels and to the posterior lobe of pituitary by the axons of its neurons.

Hormones

Hypothalamus contains several groups of neurosecretory cells, known as nuclei, which produce hormones. The function of these hormones is to regulate the synthesis and secretion of pituitary hormones.

Hormones produced by hypothalamus are of following two types

i. Releasing Hormones

These are the hormones that stimulates, the secretion of pituitary hormones, e.g., Gonadotrophin Releasing Hormone (GnRH) which stimulates the gonadotroph cells of anterior pituitary gland to release gonadotrophins.

ii. inhibiting Hormone

These are the hormones that inhibits the release of pituitary hormones, e.g., Somatostatin, which inhibits the secretion of growth hormone from anterior lobe of pituitary gland. All these hormones originating in the hypothalamic neurons, passes through the axons and are released from their nerve endings.

These hormones finally reach the pituitary gland through a portal circulatory system (hypophyseal portal system) thereby, regulating the functions of anterior pituitary. The posterior pituitary however, functions under the direct regulation of the hypothalamus.

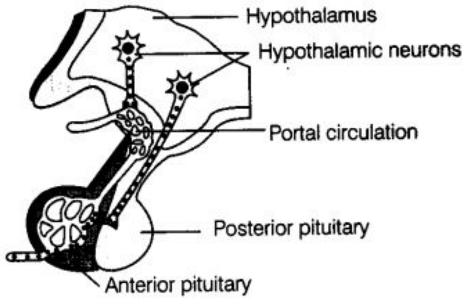


Fig. 22.2 Diagrammatic representation of pituitary and its relationship with hypothalamus

Pituitary Gland (Hypophysis)

It is the smallest endocrine gland, but serve very important role in the human endocrine system. It directly or indirectly controls almost all other endocrine glands of the body. It is also known as master gland.

Origin

It originates from the ectoderm of the embryo.

Location and Structure

It is reddish grey in colour and is roughly oval in shape. It is about a size of a pea seed. The pituitary gland is located in a small bony cavity of the brain called sella tursica.

Anatomy

The pituitary gland has three major lobes, i.e., anterior, intermediate and posterior lobe.

It is anatomically divided into two major portions

i. Adenohypophysis

It is the glandular anterior portion of the pituitary gland. It further consists of two parts, i.e., pars distalis and pars intermedia.These two parts represent the anterior and intermediate lobes of pituitary.

a. Pars Distalis

It also called anterior pituitary. It produces different hormones.

These hormones given below with their functions

Growth Hormone (GH), stimulates the somatotroph cells of anterior lobe of pituitary gland to release its Growth Hormone or somatotrophin. It stimulates body growth, protein, fat and carbohydrate metabolism. Oversecretion of this hormone during childhood causes gigantism (excessive growth of bones), whereas in adulthood causes acromegaly (abnormal thickness of bones). Its low secretion results in stunted growth, i.e., pituitary dwarfism.

Prolactin (PRL) The prolactin releasing hormone stimulates lactotroph cells of the anterior lobe of pituitary gland to secrete its prolactin. PRL regulates the growth of mammary glands and formation of milk in them.

Thyroid Stimulating Hormone (TSH) Thyroid releasing hormone stimulates thyrotroph cells of the anterior lobe of pituitary to secrete its thyroid stimulating hormone, i.e., TSH or thyrotrophin. This TSH stimulate the synthesis and secretion of thyroid hormones from the thyroid gland.

Adrenocorticotrophic Hormone (ACTH) This is secreted when adrenocorticotrophin releasing hormone (ACRH) stimulates the corticotroph cells of anterior lobe of pituitary. This stimulates the synthesis and secretion of steroid hormones called glucocorticoids from the adrenal cortex.

Gonadotrophin Hormone It is the gonadotroph cells of anterior lobe of the pituitary gland, which secrete, leuteinizing hormone (LH) and follicle stimulating hormone (FSH). Both of these hormones stimulates the gonadal activity hence, called gonadotrophin.

Leuteinising Hormone (LH) In males, it stimulates the synthesis and secretion of hormones called androgens from testis. While, in females, it induces ovulation of fully mature follicles (Graafian follicles) and also helps in maintaining the corpus luteum formed from the remnants of the Graafian follicles after ovulation.

Follicle Stimulating Hormone (FSH) In males, the FSH and androgens together regulate spermatogenesis. In females, this hormone stimulates the growth and development of ovarian follicles.
Details of both hormones (i.e, FSH and LH) and the regulation of different hormones will be studied in class XII.

b. Pars Intermedia or Intermediate Lobe
This portion of adenohypophysis secretes only one hormone,
* Melanocyte Stimulating Hormone (MSH) The melanocyte releasing hormone

stimulates the intermediate lobe of pituitary gland to secrete its melanocyte stimulating hormone. MSH acts on melanocytes (melanin containing cells) and regulates the pigmentation of the skin.
Like MSH, another hormone called Melanocyte Inhibiting Hormone (MIH) is also secreted, which inhibits the secretion melanocyte stimulating hormone.

ii. Neurohypophysis
It is a collection of axonal projections from the hypothalamus, which terminates behind the anterior pituitary gland. It is pars nervosa of the neurohypophysis that forms the posterior lobe of pituitary gland.

The posterior pituitary stores and releases two hormones given below
a. Oxytocin
It is a short peptide of nine amino acids, also known as pitocin. It acts on the smooth muscles of our body and stimulates a vigorous contraction of uterus at the time of child birth. It also plays role in ejection of milk from the mammary glands in females.

b. Vasopressin
It is a small peptide hormone, also known as antidiuretic hormone (ADH) or pitressin. This hormone acts mainly at the kidney, stimulating the reabsorption of water and electrolysis by the distal tubules. Thereby reducing the loss of water through urine (diuresis).

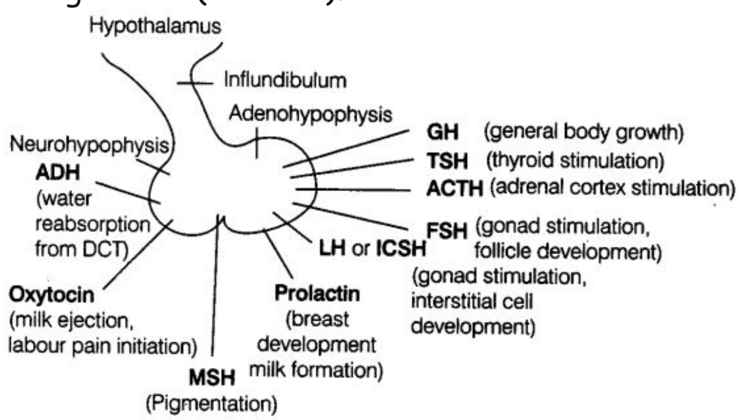


Fig 22.3 Pituitary hormone and their major effects

Note:

- During the time of parturition (delivery time) in mother, the secretion of oxytocin hormone is at its maximum. It is this hormone only, which causes labour pain at the time of birth. Thus, because of its role, it is called birth hormone and milk ejecting hormone.

- LH is also called ICSH (Interstitial Cell Stimulating Hormone) in males as it affects the interstitial cells or cells of Leydig of testes.

Hormones

It secrete a hormone called melatonin that plays a very important role in the regulation of a 24 hrs (diurnal) rhythm of our body and Melatonin also helps in maintaining the normal rhythms of sleep-wake cycle, body temperature. Metabolism, pigmentation, menstrual cycle as well as our defence capability is also influenced by this hormone.
The melatonin hormone promotes sleep, so it is also known as sleep hormone.

Thyroid Gland

The thyroid gland is known to be the largest endocrine gland.

Origin

It is endodermal in origin, i.e., originates from the endoderm of the embryo. The thyroid gland is bilobed, highly vascular organ.

Location and Structure

It surrounds the front of the larynx and is composed of two lobes. Each of its lobe is located on either side of the trachea in the neck interconnected with each other through a thin flap of connective tissue called isthmus.

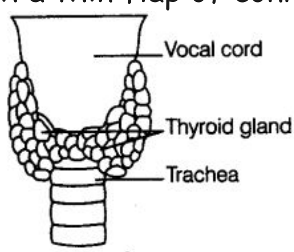


Fig 22.4 Diagrammatic view of the position of thyroid gland (ventral side)

It is composed of follicles (round in shape) held together by loose connective tissue called stromal tissues. Each thyroid follicle is composed of follicular cells, enclosing a cavity.

Hormones

The follicular cells synthesise following two hormones

(i) Tetraiodothyronine or thyroxine (T_4) hormone
(ii) Triiodothyronine (T_3) hormone.

Both these hormones are iodmated forms of the amino acid (tyrosine). They are stored in the colloid that fills the follicles and are released to the blood when needed. Iodine (in diet) is essential for the synthesis of hormone at normal rate in thyroid.

Disorders
i. Hypethysot-nisro
This disorder occurs due to the deficiency of iodine in our diet. It leads to the enlargement of thyroid gland commonly known as goitre.
(a) Hypothyroidism in women at the time of pregnancy affects the development and maturation of the growing baby and leads to stunted growth (cretinism), mental retardation, low intelligence quotient, abnormal skin, deaf-mutism, etc.

(b) Hypothyroidism in adult women may cause irregular menstrual cycle.

ii. tiiypfcitnyroidism
It is the condition during which, rate of synthesis and secretion of thyroid hormones is increased to abnormal high levels. It may occur due to the cancer of the thyroid gland or due to development of nodules of the thyroid gland. It adversly affects the body physiology of an organism.

Note:

- Hashimoto's disease, an autoimmune disorder in which the thyroid gland is destroyed by autoimmunity. All the functions of thyroid gland gets impaired during this disease.
- Myxoedema It is caused by deficiency of thyroid hormones in adults, it is more common in women and is characterised by puffy appearance due to accumulation of fat in subcutaneous tissue because of low metabolic rate and retarded oxidation.

Functions of Thyroid Hormones
Thyroid hormone serves several function in the body, such as
(i) These hormones regulates and maintains the basal metabolic rate (BMR), i.e.,

both T_3 and
T_4 hormones increases the overall metabolic rate of the body.

(ii) They support the process of formation of red blood cells. Also helps in controlling the metabolism of carbohydrates, proteins and fats.

(iii) Influences the maintenance of water and electrolyte in our body. Apart from the hormone T_3 and T_4, thyroid gland also secretes a protein hormone called thyrocalcitonin (TCT). Its main function is to regulate the level of calcium in blood.

Parathyroid Gland
These are small glands in the human neck that produces parathyroid hormone.
Origin It is endodermal in origin.

Location
These glands are situated on the posterior side of the thyroid gland.

Structure
Parathyroid glands are four in number, i.e., each pair is situated in the two lobes of the thyroid gland on either side.
These are small, flat and oval gland.

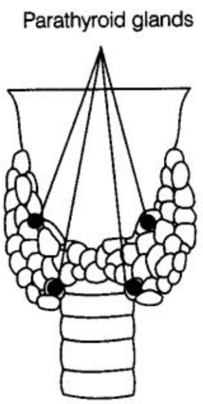


Fig. 22.5 Diagrammatic view of the position of parathyroid gland (dorsal side)

Parathyroid glands secretes a single hormone known as parathormone or parathyroid hormone (PTH) (functions opposite to the thyrocalcitonin hormone). The secretion of PTH is regulated by the circulating level of calcium ions in the blood.

Functions of Parathyroid Hormone

Parathyroid hormone serve several functions in the body, such as

(i) It increases the level of Ca^{2+} levels in the blood.

(ii) It stimulates the process of bone reabsorption (i.e., dissolution/demineralisation) by acting on bones.

(iii) It also stimulates reabsorption of Ca^{2+} by the renal tubules and absorption of Ca^{2+} from the digested food.

By the above mentioned functions of parathyroid hormone, it is clear that PTH acts as a hypercalcaemic hormone (increases the level of Ca^{2+} in the blood). Parathyroids are under the feedback control of blood calcium level. A fall in Ca^{2+} in blood stimulates them to secrete PTH. Thus, both the hormones (TCT and PTH) play a significant role to control and regulate the concentration of Ca^{2+} and phosphorus.

Note:

- Parathormone is also known as Collip's hormone after its discoverer (a Canadian endocrinologist, James B Collips; 1925).
- Hyposecretion of PTH lowers Ca^{2+} concentration in blood and tissues due to excretion of Ca in urine. This increases the nerve and muscle excitability causing cramps and convulsions. This disorder is known as parathyroid tetany.
- Hypersecretion of PTH draws more Ca^{2+} from the bones, resulting in their softening, bending and fracture. Osteoporosis is the name given to this condition.

Thymus

It is a lymphoid gland that play an important role in the development of immune system.

Origin

It arises from the endoderm of the embryo.

Structure and Location

The thymus gland is a lobular structure situated on the dorsal side of the heart and the aorta (in the upper part of thorax near the heart). It is a soft, pinkish, bilobed mass of lymphoid tissue and is a prominent gland that gets degenerated with age.

Hormones

The thymus gland secretes peptide hormone called thymosin, which plays a major role in the differentiation of T-lymphocytes, which provides cell-mediated immunity.

Thymosins, when released in the blood has a stimulating effect on the entire immune system. Apart from this thymosin also promotes production of antibodies to provide humoral immunity.

Its degeneration with age occurs due to which production of ' thymosin hormone also gets decreased. Thus, resulting in weaker immune response in old people.

Adrenal Gland (Suprarenals)

Location

Our body has a pair of adrenal glands. Each located at the anterior part of each kidney.

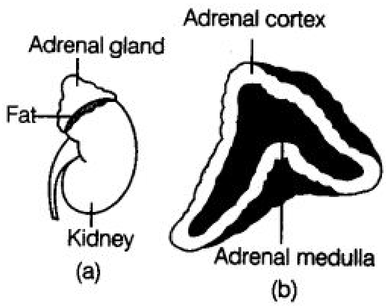


Fig. 22.6 Diagrammatic representation of adrenal gland

Structure

Adrenal glands are conical yellowish bodies composed of two types of tissues.

These are as follows

1. Adrenal Cortex

It is an external firm, pale yellowish tissue derived from mesoderm of embryo. It is further divided into three concentric layers

(a) Zona Reticularis It is the inner layer of the cortex whose cells are arranged in the net like fashion.

(b) Zona Fasciculata It is the middle layer of the cortex. It is the widest of all three layers.

(c) Zona Glomerulosa It is the outermost layer. It is composed of five layers compactly arranged cells.

Hormones secreted by these three layers of adrenal cortex are collectively known as corticoids.

Three groups of steroid hormones are secreted by adrenal cortex, such as
i. Mineralocorticoids (Aldosterone)
They regulate the balance of water and electrolytes in our body. Aldosterone is the major mineralocorticoid found in our body. It mainly acts on renal tubules stimulating the reabsorption of Na^+ and water. Also stimulate the excretion of K^+ and phosphate ions from the body.
Its main function is in maintaining electrolytes, body fluid volume, osmotic pressure and blood pressure of the body.

ii. Glucocorticoids (Cortisol)
These are the hormones, which regulate the metabolism of carbohydrates, proteins and fats. Cortisol is the main glucocorticoid found in our body.

(a) Cortisol stimulates the liver for the synthesis of carbohydrates from non-carbohydrate sources (like amino acids and glycerol). This process is known as gluconeogenesis. Hence, glucocorticoids stimulates gluconeogenesis, lipolysis and proteolysis.
(b) Inhibition of cellular uptake and utilisation of amino acids.
(c) Cortisol is involved in the maintenance of cardiovascular system and in proper functioning of kidney.
(d) Cortisol produces anti-inflammatory reactions and also functions in suppression of immune response.
(e) It stimulates the production of RBC.

iii. Sexocorticoids (Androgen)
Adrenal cortex also produces a small quantity of androgenic steroids, i.e., sex hormone (androgens) both in males and females.
These hormones are secreted as DHEA (Dehydroxy epiandrosterone), which acts as a precursor of both testosterone and estrogens.
(a) It play a major role in the growth of axial, pubic and facial hair during puberty.
(b) Development of acne are also due to these hormones in young girl.
(c) It also plays an important role in the development of embryo (foetus).

Note:

- Addison's disease is caused by deficiency of mineralocorticoids.

- Cushing's syndrome is due to excess of cortisol, while an excess of aldosterone leads to aldosteronism.
- Adrenal virilism is caused by excess of sex corticoids in a female. In this there is development of male secondary sexual characters such as beard, moustaches, etc in females.

2. Adrenal Medulla
The adrenal medulla lies in the centre of the adrenal gland. It is an internal soft, dark reddish brown tissue derived from the ectoderm.
The adrenal medulla secretes two hormones
(i) Adrenaline (epinephrine)
(ii) Noradrenaline (norepinephrine)

Activation of Adrenaline -no Noradrenaline
Both hormones belong to the category of compounds known as catecholamines and are secreted in response to any kind of stress danger and during emergency situations like fall in blood pressure or sugar level in creased respiratory rate, heart beat, etc.

The CNS at the time of stress or danger stimulates the adrenal medulla to release both these hormones. These are also known as emergency hormones or hormones of fight or flight.

These hormones serves following purposes
(a) Increases, alertness.
(b) Dilation of pupil.
(c) Piloerection (raising of hairs of hands and legs).
(d) Increase in heart beat and rate of respiration.
(e) They also stimulate the breakdown of glycogen due to which the concentration of glucose increases in the blood.
(f) Stimulate breakdown of lipids and proteins.

Pancreas
It is a composite gland that acts as both exocrine and endocrine gland.

Origin
It originates from the endoderm of the embryo.

Location
It lies below the stomach, in the loop of duodenum.

Structure
It is elongated yellowish gland that consists of large number of acini and ducts.
Besides these, pancreas consists of 1-2 millions of small group of specialised cells, called Islets of Langerhans (after the name of their discoverer Paul Langerhans in 1869).
In normal human pancreas, these cells represents only 1-2% of the pancreatic tissue.
Each islet consists of major two types of cells as
(i) α-cells (about 25%) It secretes a peptide hormone called glucagon.
(ii) β-cells (about 60%) It secretes a another peptide hormone called insulin.

Note:
Apart from a and P-cetls, Islets of Langerhans consists of two or more types of cells called delta cells or D-cells (about 10%) which secretes somatostatin hormone and PP-cells or F-cells (which secretes pancreatic polypeptide-PP).

Hormones
Glucagon and insulin have antagonistic effect on blood glucose level. This can be clearedfrom the functioning given below

i. Glucagon
This peptide hormone plays an important role in maintaining the normal blood glucose levels. It brings about change of liver glycogen to blood glucose.

Functions of Glucagon
(a) It acts mainly on liver cells (hepatocytes) and stimulates glycogenolysis, which results in an increased blood sugar known as hyperglycaemia.

(b) Apart from this glucagon also stimulates the process of gluconeogenesis which also contributes to hyperglycaemia. Glucagon is known as hyperglycaemic hormone because it reduces the cellular glucose uptake and utilisation.
(c) It reduces glycogenesis and also enhances lipolysis.
Glucagon also stimulates the secretion of insulin from beta cells by its paracrine effect.

ii. Insulin
This peptide hormone plays a major role in regulation of glucose level in the blood. It mainly acts on hepatocytes and adipocytes (cells of adipose tissue), increasing the cellular glucose uptake and utilisation.
As a result, the movement of glucose takes place rapidly from blood to liver cells and cells of adipose tissues by decreasing the blood glucose level (hypoglycaemia). Insulin act as a powerful anabolic hormone.

Deficiency Disorder of Insulin

Diabetes mellitus is the common complex disorder caused due to prolonged hyperglycaemia.
This is associated with the loss of glucose (when complete glucose cannot be reabsorbed by the kidneys) in the urine as pancreas fails to release adequate amount of insulin to. lower the level of glucose in the body.
During this disorder, cells fails to utilise glucose and other carbohydrate for production of energy instead start utilising proteins and fats for it (due to which person become weak). Diabetic patients are successfully treated with insulin therapy.
(a) Insulin stimulates the conversion of glucose to glycogen (glycogenesis) in the target cells.
(b) Decreases gluconeogenesis.
(c) Decreases glycogenolysis.
(d) Also reduces the catabolism of proteins and fats.
(e) Increases synthesis of fat in the adipose tissue from fatty acids.

Some Metabolic Conversions
Glycolysis Breakdown of glucose to pyruvic acid.
Glycogenesis Formation of glycogen from glucose.
Glycogenolysis Breakdown of glycogen to glucose.
Gluconeogenesis Conversion of fatty acids or amino acids into sugar.
Lipolysis Breakdown of fats. It forms ketone bodies, which are toxic, Lipogenesis Synthesis of fats.
Ketogenesis Formation of ketone bodies, Deamination Breakdown of amino acids to release ammonia.

Testis

These are the primary sex organ of males. They perform dual role, i.e., function as endocrine gland apart from acting as male sex organ.

Location

A pair of testis is located in the scrotal sac (outside abdomen) of male individuals.

Structure

A testes is composed of many seminiferous tubules which are lined by germinal epithelium and stromal or interstitial tissue.

This epithelium consists of three types of cells

(i) Follicular cells give rise to sperms.
(ii) Interstitial cells or Leydig cells secretes group of hormones called androgens mainly testosterone.
(iii) Sertoli cells provides nourishment to sperms and also secretes hormone (inhibin).

Hormone

Interstitial cells present in the intertubular spaces produces a group of hormones, i.e., androgens. These include testosterone, dihydrotestosterone and androstenedione.But mainly secretes testosterone.

Function

Androgen (mainly testosterone) performs a variety of functions given below
(a) It regulates the development, maturation and functions of male accessory sex organs like epididymis, vas deferens, seminal vesicles, prostate gland, urethra, etc.
(b) These hormones also stimulate changes associated with puberty in males, i.e., muscular growth, growth of facial and axillary hair, aggressiveness, low pitch of voice, etc.
(c) Also stimulates the process of spermatogenesis, i.e., formation of spermatozoa.
(d) Promotes the growth of body tissues such as bones and muscles and helps in the formation of musculine body.
(e) Also have anabolic effects (synthetic effects) on the metabolism of protein and carbohydrate.

Inhibin Hormone
Beside testosterone, another hormone is also secreted from testes by the Sertoli cells, known as inhibin. Its main function is to check and regulate the over activity of testosterone by inhibiting its secretion.
Details about spermatogenesis, male reproductive system and hormones related to it will be studied in higher classes (i.e., class XII).

Ovary
It is the primary sex organ in females that serves to produce ova (female gametes) and female sex hormones.

Location
A pair of ovaries is located in the pelvic cavity (in the abdomen).

Structure
It is an almond-shaped structure. Internally it is composed of ovarian follicles and stromal tissues.

Hormones
Ovary produces two groups of steroid hormones, i.e., estrogen and progesterone.
Estrogens are secreted by granulosa cells of Graafian follicle.
After ovulation, the ruptured follicle is converted to another structure called corpus luteum, responsible for secretion of progesterone.

Functions
Both estrogens and progesterone play a vital role in various processes in female. These are as follows

Estrogen
(a) It helps in the growth of uterine endometrium layer during each menstrual cycle.
(b) It directly influences the development of mammary glands.
(c) Regulates female sexual behaviour and stimulate growth and activities of female secondary sex organs.
(d) Plays a role in the development of growing ovarian follicles.
(e) Appearance of female secondary sex characters (deposit of fat on thigh and hip region, high pitch etc.).

Progesterone
(a) It is secreted in very high amount continuously during pregnancy (i.e., supports pregnancy by forming placenta and preventing contractions in uterine wall).
(b) It also acts on mammary glands and stimulates the formation of alveoli (sac-like structures that store milk) and milk secretion.
(c) It also help in forming a mucus plug at cervix.
Relaxin is another hormone secreted by ovary in the later stages of pregnancy. Its main role is in softening ligament, widening pelvic cavity, also affects other ligaments such as of foot etc. Due to which women may experience increase in their foot size during pregnancy.

Topic 2 Endocrinology: Various Tissue Hormones and Mechanism of Hormone Action

We have studied about various endocrine glands of the body and hormones secreted by them till now. However, certain endocrine tissues are not organised to form compact endocrine gland, but are present isolated in the body, i.e., hormones are also secreted by some tissues.

Some examples of hormones secreted by various tissues are as follows
Hormones of Heart
A very important peptide hormone known as Atrial Natriuretic Factor (ANF) is secreted by the atrial walls of our heart, when blood pressure is increased. Its secretion causes dilation of blood vessels thereby reducing the blood pressure.

Hormones of Kidney
A peptide hormone called erythropoietin is produced by the juxtaglomerular cells of kidney. This hormone stimulates formation of RBC, i.e., erythropoiesis. It is done by activating increased erythropoiesis in haemopoietic tissues.

Hormones of Gastro-intestinal Tract
GI tract develops from the endoderm of the embryo. Endocrine cells that are present in different parts of this and tract secretes four major peptide hormones.

These are as follows
(i) Gastrin, which acts on the gastric glands and stimulates the secretion of hydrochloric acid and pepsinogen.

(ii) Secretin, which acts on the exocrine portion of pancreas (remember pancreas is a mixed gland, performing both exocrine and endocrine roles), stimulating secretion of water and bicarbonate ions.

(iii) Cholecystokinin (CCK) This hormones acts on both pancreas and gall bladder stimulating secretion of pancreatic enzymes and bile juice respectively.

(iv) Gastric Inhibitory Peptide (GIP), which is secreted by intestinal mucosa. Its function is to stop or inhibit the secretion of gastric juice and its motility into stomach.
Apart from all these hormones, several other non-endocrine tissues secrete hormones known as growth factors. These factors are essential for normal growth, repair and regeneration of tissues.

Mechanism of Hormone Action
Hormones are released from their respective gland in very small amount. They carry out widespread effects in the body of an individual. Their response is very specific and accurate. Their effects are produced on target tissues by binding to the specific proteins known as hormone receptors, located in the target tissues only.

Types of Hormones
On the basis of the chemical nature, hormones are divided into following four groups
(i) Peptide, Polypeptide, Protein Hormones (e.g., insulin, glucagon, pituitary hormones, hypothalamic hormones, etc).
(ii) Steroids (e.g., cortisol, testosterone, estradiol and progesterone).
(iii) Iodothyronines (e.g., thyroid hormones).
(iv) Amino acid derivatives (e.g., epinephrine).

Types of Hormone Receptors
Hormone receptors are offblbwing two types
(i) Membrane bound receptors Hormone receptors present on the cell membrane of the target cells.
(ii) Intracellular receptors Hormone receptors present inside the target cell, e.g., Nuclear receptor (present in the nucleus of a cell).

Action of Hormone Through Extracellular Receptor

Hormones that interact with the membrane bound receptors do not enter their target cell in normal condition, but generate secondary messengers such as cyclic AMP (cAMP), IP_3, Ca^{2+}
etc., which regulate cellular metabolism of the body. e.g., Protein or peptide hormone.
Hormones do not participate in a metabolic reaction themselves, they instead acts as messengers only, i.e., primary messengers.

Functioning of Peptide Hormone

Protein hormone is water soluble in nature, binds to the extrinsic receptors (present on cell surface) to form the hormone-receptor complex. The formation of this complex causes the release of enzyme adenylate cyclase. This activated enzyme, thus leads to the formation of CAMP (i.e„ cyclic Adenosine monophosphate) from ATP in the cell from the receptor site.

$$ATP \xrightarrow[\text{adenyl cyclase} + Mg^{2+}]{\text{Activated}} cAMP + PPi$$

The hormone receptor complex changes the permeability of the cell membrane to facilitate the passage of materials through it (and thereby, regulates cellular activities of the cell causing specific response to occur).
Generation of second messenger (cyclic AMP or Ca^{2+}) chromosome function by interaction of hormone-receptor complex with the genome, e.g., Steroid hormone, iodothyronines, etc.

Functioning of Steroid Hormone

Steroid hormones are lipid soluble in nature, so they can easily diffuse through the cell membrane and bind to receptor molecules present in the cytoplasm to form a hormone-receptor complex that enters the nucleus.

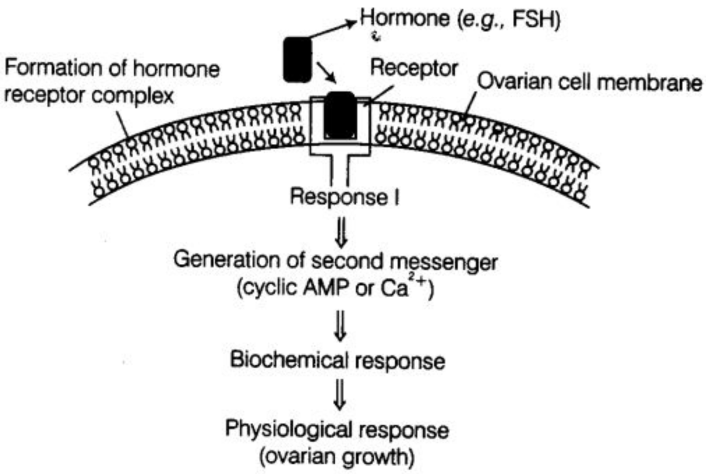


Fig 22.7 Diagrammatic representation of the mechanism of hormone action of peptide or protein hormone

Action of Hormone Through Intracellular Receptors

Hormones that interact with intracellular receptors are mostly involved in the regulation of gene expression .

In nucleus, they bind to specific intracellular receptor site on chromosomes and regulate gene expression that results in physiological responses. Thus, the cumulative biochemical actions result in physiological and developmental effects.

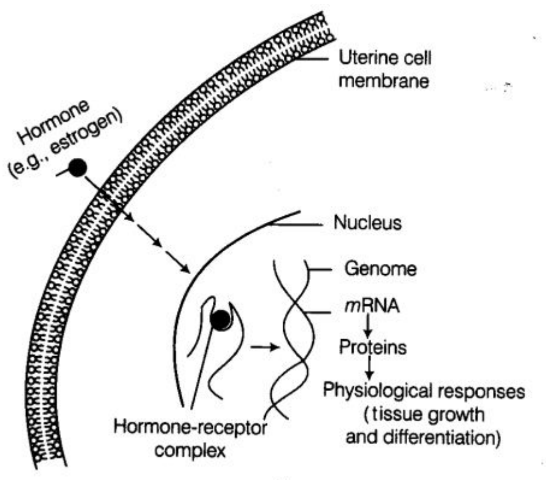


Fig. 22.8 Mechanism of hormone action : Steroid hormone

Antagonistic and Synergistic Interactions of Hormones

Hormones can show both antagonistic and synergistic interactions among each other. In antagonistic interactions effects of two hormones are opposite to each other on the target cells, e.g., insulin and glucagon hormones, act antagonistically on blood glucose level.

In synergistic interaction, two or more hormones tend to complement each other for their effect on target cells, e.g., estrogen, progestrone, oxytocin, prolactin all acts synergistically for the secretion, production and ejection of milk in mammary glands.

MCQ Questions for Class 5
Chemical Coordination and Integration with Answers

Question 1.
Which of the following is an emergency hormone?
(a) Norepinephrine
(b) Androgen
(c) Cortisol
(d) FSH

Answer
Answer: (a) Norepinephrine
Explanation:
Adrenaline (epinephrine) and noradrenaline (norepinephrine) are called as catecholamines.
These hormones are secreted in response to stress and during emergency. So these are called emergency hormones or hormones of flight and fight.

Question 2.
Secretin causes stimulation of
(a) water
(b) bile juice
(c) gastric secretion
(d) pepsinogen

Answer
Answer: (a) water
Explanation:
Secretin acts on the exocrine pancreas and stimulates secretion of water and bicarbonate ions.

Question 3.
Match the columns.
1. PRL – A. Pigmentation of skin

2. LH – B. Steriod hormones
3. ACTH – C. Formation of milk
4. MSH – D. Gonadal activity
(a) 1-C, 2-D, 3-B, 4-A
(b) 1-C, 2-D, 3A, 4-B
(c) 1-D, 2-C, 3-B, 4-A
(d) 1-B, 2-C, 3-D, 4-A

Answer
Answer: (a) 1-C, 2-D, 3-B, 4-A
Explanation:
Column I shows the names of hormones and column II shows the functions of the hormones.

Question 4.
In adults, insufficient thyroxine can lead to ______.
(a) Goiter
(b) Tetany
(c) Cretinism
(d) Myxedema

Answer
Answer: (d) Myxedema

Question 5.
In the body, both the blood sodium and potassium levels are regulated by ________.
(a) Pheromones
(b) Aldosterone
(c) Cortisol
(d) Androgens

Answer
Answer: (b) Aldosterone

Question 6.
Chemical name of T_4 is
(a) Tetradiodothyronine

(b) Tridiodothyronine
(c) Tetraiodothyronine
(d) Triiodothyronine

Answer
Answer: (c) Tetraiodothyronine
Explanation:
Chemical name of T_4 is tetraiodothyronine.
Chemicl name of T_3 is triiodothyronine.

Question 7.
Anabolic steroids are _______ versions of testosterone.
(a) Effective
(b) Synthetic
(c) Natural
(d) Ineffective

Answer
Answer: (b) Synthetic

Question 8.
Which of the following acts on bones?
(a) Melatonin
(b) Triiodothyronine
(c) GH
(d) Parathyroid

Answer
Answer: (d) Parathyroid
Explanation:
Parathyroid hormone acts on bones and stimulates the process of bone resorption.

Question 9.
Glucagon hormone is secreted by the _______.
(a) Thyroid gland
(b) Adrenal gland
(c) Pituitary gland
(d) Pancreas

Answer
Answer: (d) Pancreas

Question 10.
Which one of the followings are male sex hormones?
(a) Insulins
(b) Aldosterones
(c) Androgens
(d) Pheromones

Answer
Answer: (c) Androgens

Question 11.
Choose the incorrect statement.
(a) Hormones are non-nutrient chemicals.
(b) Exocrine glands are ductless glands.
(c) Invertebrates have simple endocrine system.
(d) All of the above statements are incorrect.

Answer
Answer: (b) Exocrine glands are ductless glands.
Explanation:
Endocrine glands lacks ducts and are called as ductless glands.

Question 12.
Endemic goitre is a state of
(a) Increased thyroid function
(b) Normal thyroid function
(c) Decreased thyroid function
(d) Moderate thyroid function

Answer
Answer: (c) Decreased thyroid function

Question 13.
Match the columns.

1. PRL – A. Pigmentation of skin
2. LH – B. Steriod hormones
3. ACTH – C. Formation of milk
4. MSH – D. Gonadal activity
(a) 1-C, 2-D, 3-B, 4-A
(b) 1-C, 2-D, 3-A, 4-B
(c) 1-D, 2-C, 3-B, 4-A
(d) 1-B, 2-C, 3-D, 4-A

Answer
Answer: (a) 1-C, 2-D, 3-B, 4-A
Explanation:
Column I shows the names of hormones and column II shows the functions of the hormones.

Question 14.
PTH is called as hypercalcemic hormone because it leads to the
(a) absorption of $CaCO_3$ from the digested food
(b) reabsorption of water from renal tubules
(c) increasing blood calcium levels
(d) maintainence ion balance in blood

Answer
Answer: (c) increasing blood calcium levels
Explanation:
This is called so because PTH stimulates the reabsorption of calcium by the renal tubules and increases calcium absorption from the digested food.

Question 15.
Corpus luteum secretes
(a) progesterone
(b) estrogen
(c) glucagon
(d) vasopressin

Answer
Answer: (a) progesterone
Explanation:

After ovulation, ruptured follicle gets converted to corpus luteum which secretes progesterone.

Question 16.
In adults, insufficient thyroxine can lead to ______.
(a) Goiter
(b) Tetany
(c) Cretinism
(d) Myxedema

Answer
Answer: (d) Myxedema

Question 17.
In children, hypothyroidism (underactive thyroid gland) can lead to ______
(a) Goiter
(b) Acromegaly
(c) Cretinism
(d) Myxedema

Answer
Answer: (c) Cretinism

Question 18.
Diurnal rhythm of the body is maintained by
(a) melatonin
(b) isthmus
(c) PTH
(d) norepinephrine

Answer
Answer: (a) melatonin
Explanation:
Pineal gland secretes melatonin.
It plays a very important role in the regulation of a 24-hour (diurnal) rhythm of our body.

Question 19.
Which hormone inhibits the release of growth hormone?
(a) Insulin
(b) Gonadotrophin
(c) Somatostatin
(d) Thymosin

Answer
Answer: (c) Somatostatin
Explanation:
Hypothalamus produces two kinds of hormones: releasing hormone and inhibiting hormones.
GnRH is releasing hormone which stimulates pituitary synthesis.
Somatostatin inhibits the release of GH from the pituitary.

Question 20.
Which of the following is essential for thyroid gland?
(a) NaCl
(b) I_3
(c) $CaCO_2$
(d) H_2CO_3

Answer
Answer: (b) I_3
Explanation:
Iodine is essential for thyroid gland.

Solutions for Class 11 Biology Chapter 22 Chemical Coordination and Integration:

Section Name	Topic Name
22	Chemical Coordination and Integration
22.1	Endocrine Glands and Hormones
22.2	Human Endocrine System
22.3	Hormones of Heart, Kidney and Gastrointestinal Tract
22.4	Mechanism of Hormone Action
22.5	Summary

TEXTBOOK QUESTIONS FROM SOLVED

1. Define the following:
(a) Exocrine gland,
(b) Endocrine gland,
(c) Hormone.

Solution:

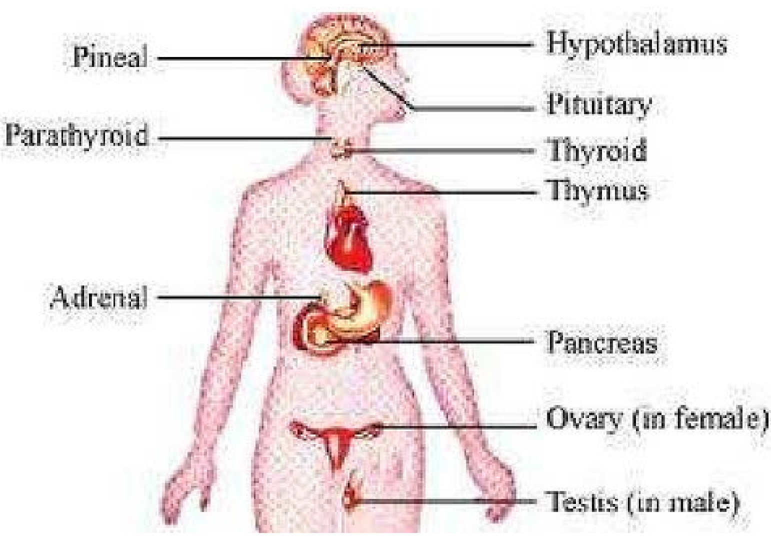
(a) Exocrine gland is a gland that pours its secretion on the surface or into a particular region by means of ducts for performing a metabolic activity, e.g., sebaceous glands, sweat glands, salivary glands and intestinal glands.

(b) Endocrine gland is an isolated gland (separates even from epithelium forming it) which secretes informational molecules or hormones that are poured into venous blood or lymph for reaching the target organ because the gland is not connected with the target organ by any duct. Therefore endocrine gland is also called ductless gland e.g. thyroid gland.

(c) Hormone is a substance that is manu-factured and secreted in very small quantities into the blood stream by an endocrine gland or a specialized nerve cell and regulates the growth or functioning of a specific tissue organ in a distant part of the body e.g insulin.

2. Diagrammatically indicate the location of the various endocrine glands in our body.

Solution:



3. List the hormones secreted by the following:
(a) Hypothalamus
(b) Pituitary

(c) Thyroid
(d) Parathyroid
(e) Adrenal
(f) Pancreas
(g) Testis
(h) Ovary
(i) Thymus
(j) Atrium
(k) Kidney
(l) G-I Tract.

Solution:

(a) Two types of hormones are produced by hypothalamus : releasing hormones (that stimulate secretion of pituitary hormones) and inhibiting hormones (that inhibit secretion of pituitary hormones).
These hormones are:

1. Thyrotrophin-releasing hormone Adreno-
2. corticotrophin-releasing hormone
3. Follicle-stimulating hormone-releasing hormone
4. Luteinizing hormone-releasing hormone
5. Growth hormone-releasing hormone
6. Growth inhibiting hormone
7. Prolactin releasing hormone
8. Prolactin inhibiting hormone
9. Melanocyte stimulating hormone¬releasing hormone
10. Melanocyte stimulating hormone- inhibiting hormone.

(b) Different parts of pituitary secrete different hormones.
Hormones secreted by anterior lobe of pituitary are:

1. Follicle stimulating hormone
2. Luteinizing hormone
3. Thyroid stimulating hormone
4. Adrenocorticotrophic hormone
5. Somatotrophic or Growth hormone
6. Prolactin hormone or Luteotrophic hormone.

Middle (intermediate) lobe of pituitary : Melanocyte stimulating hormone.
Posterior lobe of pituitary:

(i) Oxytocin
(ii) Vasopressin or antidiuretic hormone.

(c) Thyroid secretes 3 hormones:

1. Thyroxine or tetraiodothyronine
2. Triiodothyronine
3. Calcitonin.

(d) Parathyroid gland secretes a single hormone called parathormone (PTH) or Collip's hormone.

(e) Adrenal glands have two regions, namely, outer adrenal cortex and inner adrenal medulla. Both these regions secrete different hormones.
Hormones of adrenal cortex are grouped into three categories:

1. Glucocorticoids, e.g., cortisol
2. Mineralocorticoids, e.g., aldosterone
3. Sexcorticoids e.g testosterone. Adrenal medulla secretes two hormones
   (i) Epinephrine (adrenaline)
   (ii)Nor-epinephrine (nor-adrenaline).

(f) Pancreas secretes following hormones:

1. Insulin
2. Glucagon
3. Somatostatin.

(g) Testis secretes androgens such as testosterone.

(h) Ovary secretes:

1. Estrogens such as estradiol
2. Progesterone
3. Relaxin.

(i) Thymus secretes thymosin hormone.

(j) Atrium secretes atrial natriuretic factor (ANF).

(k) Kidney secretes:
(i) Renin (ii) Erythropoetin

(l) G.I. tract secretes :

1. Gastrin
2. Secretin
3. Cholecystokinin
4. Enterocrinin
5. Duocrinin
6. Villikinin.

4. Fill in the blanks:

Hormones	Target gland
(a) Hypothalamic hormones	………………..
(b) Thyrotrophin (TSH)	………………..
(c) Corticotrophin (ACH)	………………..
(d) Gonadotrophins (LH, FSH)	………………..
(e) Melanotrophin (MSH)	………………..

Solution:
(a) Pituitary
(b) Thyroid
(c) Adrenal cortex
(d) Gonads -Testes in male and ovaries in female
(e) Skin.

5. Write short notes on the functions of the following hormones:
(a) Parathyroid hormones (PTH)
(b) Thyroid hormones
(c) Thymosin
(d) Androgens
(e) Estrogens
(f) Insulin and Glucagon.
Solution:
(a) Parathyroid hormone increases the level of calcium and decreases the level of phosphate in the blood.

(b) Thyroid gland secretes three hormones: thyroxine, triiodothyronin and calcitonin. Thyroxine and triiodothyronin control the general metabolism of the body, promote growth of body tissues and stimulates tissue differentiation. Calcitonin regulates the concentration of calcium in the blood.
(c) Thymosin is secreted by thymus. It accelerates cell division, stimulates the development and differentiation of T-lymphocytes and also hastens attainment of sexual maturity.
(d) Androgens are secreted by testis. They stimulate the development of male reproductive system, formation of sperms, development of male accessory sex characters and also determines the male sexual behaviour and the sex urge.
(e) Estrogens are secreted by ovaries. They stimulate the female reproductive tract to grow to full size and become functional, differentiation of ova and development of accessory sex characters.
(f) Insulin is secreted by the |3-cells of the pancreas. It lowers blood glucose level, and promotes synthesis of proteins and fats. Glucagon is secreted by the a-cells of the pancreas. It increases the level of glucose in the blood.

6. Give example(s) of
(a) Hyperglycemic hormone and hypoglyce-mic hormone
(b) Hypercalcemic hormone
(c) Gonadotrophic hormones
(d) Progestational hormone
(e) Blood pressure lowering hormone
(f) Androgens and estrogens.
Solution:
(a)Glucagon, Insulin
(b) Parathormone (PTH)
(c) Follicle stimulating hormone (FSH) and Luteinizing hormone (LH)
(d) Progesterone
(e) Atrial natriuretic factor
(f) Testosterone and Estradiol.

7. Which hormonal deficiency is responsible for the following:
(a) Diabetes meilitus
(b) Goitre
(c) Cretinism.
Solution:
(a) Insulin

(b) Thyroxine and Triiodothyronine
(c) Thyroxine and Triiodothyronine.

8. Briefly mention the mechanism of action of FSH.

Solution: (Folliclestimulatinghormone)being glycoprotein is insoluble in lipids, therefore,
cannot enter the target cells. It binds to the specific receptor molecules located on the surface of the cell membrane to form hormone – receptor complex. This complex causes the release of an enzyme adenylate cyclase from the receptor site. This enzyme forms the cell cyclic adenosine monophosphate (cAMP) from ATP. The cAMP activates the existing enzyme system of the cell. This accelerates the metabolic reactions in the cell. The hormone is called the first messenger and the cAMP is termed the second messenger. The hormone- receptor complex changes the permeability of the cell membrane to facilitate the passage of materials through it. This increases the activities of the cell as it receives the desired materials.

9. Match the following :

Column I	Column II
(a) T_4	(i) Hypothalamus
(b) PTH	(ii)Thyroid
(c) GnRH	(iii)Pituitary
(d) LH	(iv) Parathyroid.

Solution:

(a) – (ii); (b) – (iv); (c) – (i); (d) – (iii)