CHAPTER 1
INTRODUCTION TO BIOLOGY

Learning Outcomes

It is expected that students will

- explain how the study of biology is important in daily life
- identify the common characteristics of living things
- know how living things are classified into three domains and six kingdoms

1.1 THE STUDY OF BIOLOGY

Biology is the study of living things. A large variety of living things exists on the land, in the water and in the air. Living things (organisms) include plants, animals including humans and other organisms. Thus, biology deals with the study of all organisms that live or have ever lived on the earth.

1.1.1 The Importance of Biology in Everyday Life

Biology is very fundamental and important science dealing with bacteria, protista, fungi, plants and animals including humans. Their structures and functions are associated with one another in their respective environments. To a great extent, we owe our daily high standard of living to biological advances in two areas: food production and disease control.

Plant and animal breeders have modified organisms to yield greater amounts of food than did older varieties. The improvements in the plants, along with better farming practices, have greatly increased food production.

Biological research has also improved food production by developing controls for the disease organisms, pests and weeds that reduce yields. Biologists must understand the nature of these harmful organisms to develop effective control methods.

1.1.2 The Different Fields of Study in Biology

The main branches of biology are:

Botany : study of plants
Zoology : study of animals
Microbiology : study of microscopic organisms

Some other branches of biology are:

Morphology : study of forms and structures of organisms
Anatomy : study of gross internal structures
Histology : study of microscopic structures of tissues
Cytology : study of cells
Physiology : study of living processes or functions of the various parts of organisms
Embryology : study of early development of organisms
Palaeontology : study of fossils (the remains of organisms that lived millions of years ago; now preserved in rocks)

Taxonomy : study of classification of organisms
Ecology : study of the relationships of organisms to their environments
Biodiversity : study of varieties among living organisms
Evolution : study of the origin and change in forms of organisms over time
Genetics : study of heredity and variations
Mycology : study of fungi
Protistology : study of protists
Phycology : study of algae
Virology : study of viruses
Bacteriology : study of bacteria
Molecular Biology : study of molecules in organisms
Biotechnology : study of utilization of living organisms in industrial processes
Bioinformatics : study of information technology to interpret molecular biology data

1.1.3 Characteristics of Living Things

The main characteristics of living things are their cellular structure, metabolism, growth, movement, irritability, reproduction and adaptability.

Cellular structure

All living things consist of the living substance called protoplasm which forms the basis of cells. These cells contain DNA (deoxyribonucleic acid) molecules that carry biological information. Cells of plants and animals are organized into tissues and tissues are in turn organized into organs and systems. These structures are responsible for carrying out the various life processes.

Metabolism

Metabolism is the sum of the various processes that give the organism's life. The two aspects of metabolism are anabolism and catabolism. The food material is made into a part of the organism in the process of anabolism. The food material, when broken down, releases energy and results in the formation of waste products. This process is termed as catabolism. The important metabolic processes that take place in organisms involve the utilization of food. This includes nutrition, respiration and excretion.

Growth

The growth of an organism is seen as an increase in size and weight resulting from the use of food to further develop structures in the organism.

Movement

All living things show some kinds of movement. This is more obvious in animals since they have organs of movement or locomotion. Movements in plants mainly take place inside the cells although some results from a stimulus such as light.

Irritability

Living things respond to stimulus. The stimulus can be any changes in the environment (light, sound, touch, temperature, etc.) which brings about a reaction in an organism due to a sensitivity to the stimulus.

Reproduction

Reproduction is the production of a new generation of offspring. The two types of reproduction are asexual reproduction and sexual reproduction. In asexual reproduction, the new individual may be produced by a part of the old one. There is only one parent organism needed for asexual reproduction.

Sexual reproduction produces a new individual as a result of the fusion of two parental sex cells. These two cells come, one from each individual of the same species. The cells are fused to form a single new organism.

Adaptability

Living organisms are able to adjust and adapt themselves to changes in their external and internal environments. Adaptability increases the chances of species surviving and can result in the formation of a new species. For instance, a change of seasons or a shortage of food may cause certain birds to migrate to another place where the conditions are more favourable. A plant may grow very straight and upright to stand above plants around it. This enables this plant or plant species to get enough sunlight to survive and even to dominate the environment.

1.2 TAXONOMY

The science of classification of organisms is taxonomy. This is the general name for groups or categories within a classification system.

1.2.1 Diversity of Organisms

There are vast numbers of living things in the world. The word 'biodiversity' is a short form of 'biological diversity' which means that the abundance of different types of species.

Scientists are not aware just how many different types of organisms exist in nature. It is because, previously unknown species are being discovered all the time.

1.2.2 Taxonomy in the Study of Biology

Classification is essential to biology because there are too many different living things to sort out and compare unless they are organized into manageable categories. With an effective classification system in use, it is easier to organize the ideas about organisms and make generalizations.

The scheme of classification has to be flexible, allowing newly discovered living organisms to be added into the scheme where they fit best. As living and extinct species are related, fossils should also be considered in this scheme.

The process of classification involves:

- giving every organism an agreed name
- placing the organism into a group based on the common characteristics it shares with others in the group.

1.2.3 The Importance of Taxonomy

By taxonomy, it is much easier to learn biology as there are millions of known and unknown organisms. Taxonomy can be used to examine the evolutionary history of organisms and the relationships between organisms.

1.2.4 Taxonomic Hierarchy

Biological classification schemes are the invention of biologists, based upon the best available evidence at that time. In classification, the aim is to use as many characteristics as possible in placing similar organisms together. Just as similar **species** are grouped together into the same **genus** (*plural* genera).

Similar genera are grouped together into **families**. This approach is extended from families to **orders**, then **classes**, **phyla** or **divisions** and **kingdoms**. This is the hierarchical scheme of classification, each successive group containing more and more different kinds of organisms. When a classification of a species is written, it starts with the kingdom followed by other taxonomic ranks of division or phylum, class, order, family, genus and species.

For examples,

Kingdom	: Plantae	Kingdom	: Animalia
Division	: Magnoliophyta	Phylum	: Chordata
Class	: Monocotyledons	Class	: Mammalia
Order	: Cyperales	Order	: Primates
Family	: Poaceae	Family	: Hominidae
Genus	: *Oryza*	Genus	: *Homo*
Species	: *O. sativa*	Species	: *H. sapiens*

1.2.5 Classification of Plants and Animals

Everyone must be able to identify objects and to relate their observations to other people. Most people are familiar with some of the common forms of plants and animals. However, since there are so many different kinds of plants as well as animals, the word 'plant' or 'animal' is not sufficient for identification.

Linnaeus (1707-1778), a Swedish naturalist, studied and gave scientific names to thousands of plants and animals. He introduced the **Binomial System of Nomenclature** in the year 1753. Each plant and animal is given a two-word name by this system. The first name is the **genus** and the second is the **species**. The name of the genus is always started with a capital letter and the name of the species is started with a small letter. These two names constitute the scientific name of the organism. For example, the scientific name of human is *Homo sapiens* and that of paddy plant is *Oryza sativa.*

1.3 KINGDOMS

A **Kingdom** is a subdivision of a **Domain**. The living things are classified and placed in one of the six kingdoms. The three domains - **Bacteria**, **Archaea** and **Eukarya** diverged early in the history of life. Subsequently, many new kinds of organisms have evolved. Each of these kingdoms has its own set of characteristics.

1.3.1 Kingdoms of Living Things

Organisms are divided into six kingdoms. There are two kingdoms within the domains **Archaea** and **Bacteria**, namely kingdoms **Archaebacteria** and **Eubacteria**. Their differences are based primarily on the metabolism and genetic composition of the organisms. Within the domain **Eukarya**, there are four kingdoms: **Protista**, **Fungi**, **Plantae** and **Animalia** (Table 1.1 and Figure 1.1).

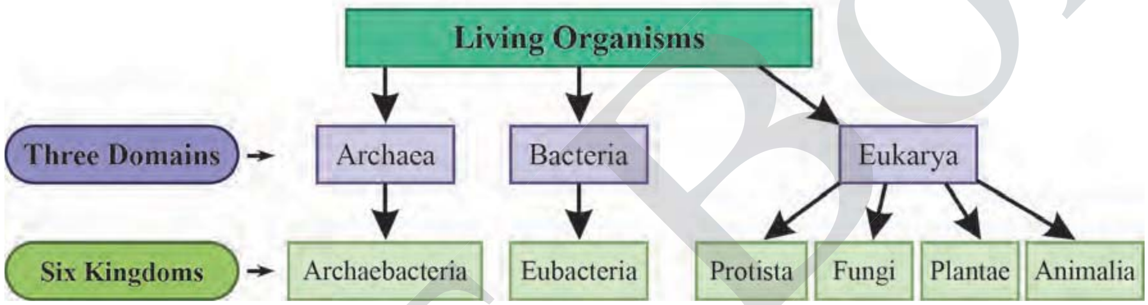


Figure 1.1 Relationship between three domains and six kingdoms of classification

Table 1.1 Characteristics of six kingdoms

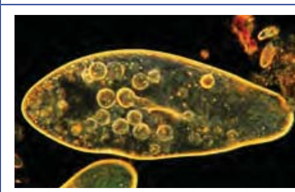
Kingdoms	Characteristics	Examples	Diagrams
Archaebacteria	- Primitive - Live in extreme environment - Prokaryote - Unicellular - Obligate anaerobic	Thermophiles Methanogens	 Thermophiles
Eubacteria	- Prokaryote - Unicellular - Autotrophs or heterotrophs - Asexual reproduction by fission	Bacteria Cyanobacteria	 Bacteria
Protista	- Eukaryote - Unicellular - Autotrophs or heterotrophs - Asexual or sexual reproduction	*Amoeba* *Euglena* Slime mold *Paramecium*	 *Paramecium*

Table 1.1 Characteristics of six kingdoms (continued)

Kingdoms	Characteristics	Examples	Diagrams
Fungi	- Eukaryote - Unicellular or multicellular - Heterotrophs - Asexual or sexual reproduction	Yeast *Rhizopus* Mushroom	 Mushroom
Plantae	- Eukaryote - Multicellular - Autotrophs - Vegetative, asexual or sexual reproduction	Algae Liverworts Mosses Ferns Conifers Angiosperms	 Angiosperm
Animalia	- Eukaryote - Multicellular - Heterotrophs - Asexual or sexual reproduction	Earthworms Insects Fish Birds Mammals	 Mammal

Viruses

Viruses are not included in the six kingdoms of living organisms. Viruses, although not considered as living organisms, cause common diseases such as colds and influenza (Figure 1.2) and also more serious ones such as AIDS (Acquired Immune Deficiency Syndrome).

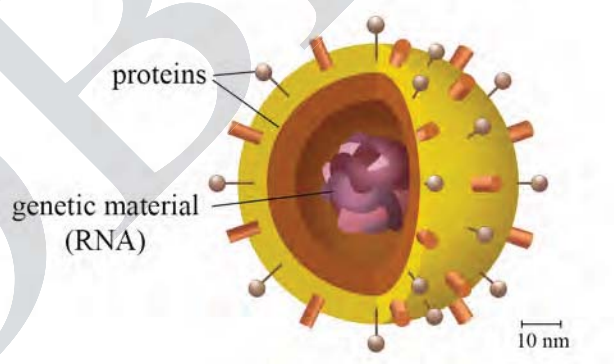


Figure 1.2 An influenza virus

Characteristics of viruses

1. Viruses are not generally considered to be alive.
2. They are very small (20-400 nm) non-cellular particles.
3. Each virus particle contains DNA or RNA covered by a protein coat.

4. They are parasites and causing diseases in plants and animals.
5. Virus in infected cells can make copies of themselves for reinfection in other host cells.
6. Viruses cannot move, feed, excrete, show sensitivity or grow and can reproduce only in the living host cells.
7. Virus cannot survive outside the host cells.

1.3.2 Kingdom Protista

The term protist means "any eukaryotic organism that is not a plant, animal or fungus". About 60,000 protist species have been described. They are the most diverse of the four kingdoms in the domain Eukarya. The kingdom Protista contains unicellular and colonial groups.

Characteristics of protista

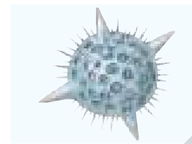
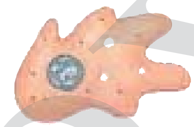
1. They live in water, but a few species live in moist area. Some can even live in the human intestine.
2. Nucleus and other organelles are present.
3. Movement is often by flagella, cilia or pseudopodia.
4. Contractile vacuole helps the cell remove excess water.
5. They reproduce asexually by fission, budding or fragmentation.
6. Most protists can be divided into three main groups based on their characteristics:
    a. **Plant-like protists –** contain chlorophyll in chloroplasts and make their own food (autotrophs) (e.g., *Euglena*).
    b. **Animal-like protists –** no chlorophyll, feed on other organisms (heterotrophs) and can move from place to place (e.g., *Amoeba*).
    c. **Fungus-like protists –** no chlorophyll, feed on dead organic matter (heterotrophs) and lack chitin in their cell walls (e.g., slime mold, water mold).

The protists include six general groups according to the characteristics (Table 1.2).

Table 1.2 Divisions/Phyla of protists

Divisions/Phyla	Characteristics	Examples
AUTOTROPHIC PROTISTS		
Chlorophyta	- Photosynthetic, unicellular, without flagella, contains chlorophylls	 *Chlorella*
Euglenophyta	- Some photosynthetic, others heterotrophic, unicellular, contains chlorophylls or none	 *Euglena*

Table 1.2 Divisions/Phyla of protists (continued)

Divisions/Phyla	Characteristics	Examples
HETEROTROPHIC PROTISTS		
Chrysophyta	- Unicellular, manufactures the carbohydrate chrysolaminarin, unique double shells of silica, contains chlorophylls	 *Diatom*
Rhizopoda	- Movement by pseudopodia, lack chromatophores (pigment containing cells), possess a single nucleus, asexual reproduction by binary fission	 *Amoeba*
Actinopoda	- Glassy skeletons, needle-like pseudopods	 *Actinosphaerium*
Foraminifera	- Rigid shells, move by protoplasmic streaming	 *Podia*

1.3.3 Kingdom Fungi

Characteristics of fungi

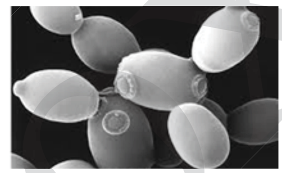
1. A collection of hyphae, thin thread-like filaments form the mycelia.
2. Chlorophyll is absent and unable to carry out photosynthesis.
3. They grow as parasites on other organisms or as saprophytes on decaying organic matter in the soil and water.
4. Cell wall of hypha is made up of chitin.
5. They reproduce in a variety of ways: vegetatively, asexually or sexually.

The fungi are subdivided into five divisions (Table 1.3).

Table 1.3 Divisions of fungi

Divisions	Characteristics	Examples
Chytridiomycota	- The simplest and most primitive form - Coenocytic hyphae (no septum) - Unicellular or multicellular - Sexual or asexual reproduction	 Chytrids

Table 1.3 Divisions of fungi (continued)

Divisions	Characteristics	Examples
Zygomycota	- Conjugated fungi - Aseptate hyphae with many nuclei (coenocytic) - Formation of zygospore in sexual reproduction	 *Rhizopus*
Ascomycota	- Sac fungi - Hypha is septate and branched except in yeast (unicellular). - Mostly reproduce by budding	 Yeast
Basidiomycota	- Club fungi - Unicellular or multicellular - Sexual or asexual reproduction - Club-shaped fruiting bodies (basidia) present	 Mushroom
Deuteromycota	- Imperfect fungi - Septate hyphae - Strictly asexual reproduction by means of conidia	 *Penicillium*

1.3.4 Kingdom Plantae

Characteristics of plantae

1. Plants are eukaryotic and chlorophyll containing organisms.
2. They obtain their energy from sun through photosynthesis.
3. Cell wall of plant is composed of cellulose.
4. Plants reproduce by vegetative, asexual and sexual methods.
5. In life cycle of plants, interchanges occur from the embryo and are supported by other tissues.
6. They lack motility.

The plantae are subdivided into five divisions (Table 1.4).

Table 1.4 Divisions of plantae

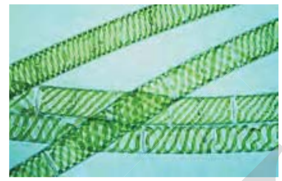
Divisions	Characteristics	Examples
Thallophyta	- Plant body is simple (thallus). - Grow in water, on damp soil, on wet rocks and on tree trunks - Vascular system absent - Reproduce by means of asexual or sexual - No embryo formation	 *Spirogyra*
Bryophyta	- Most primitive land plants - Grow on damp and shaded soil - Thallus dorsiventral with thread-like rhizoids - No vascular system - Have parenchymatous tissue - Sporophyte upright, foliose type - Life cycle of bryophytes shows two distinct generations (gametophytic and sporophytic generations). - Those two generations regularly alternate with each other in a single life cycle, is called alternation of generations.	 Liverworts (*Riccia*)  Hornworts (*Anthoceros*)  Mosses (*Funaria*)
Pteridophyta	- More advanced than bryophytes - Grow chiefly in shaded moist places - Differentiated into rhizome, rachis and pinna - A well-developed vascular system - Reproduction by spores - Life cycle shows distinct alternation of generations.	 Ferns (*Adiantum*)
Gymnospermae	- Woody, non-flowering plants - Seed-bearing vascular plants - Seeds are not enclosed in a fruit. - Seeds develop either on the surface of scale or leaf-like appendages known as sporophylls.	 Coniferous trees (Pine)

Table 1.4 Divisions of plantae (continued)

Divisions	Characteristics	Examples
Angiospermae	- Flowering vascular plants - The plants with roots, stems and leaves - Widely distributed on the earth's surface - Reproduce by means of flowers, fruits and seeds - Seeds are produced inside the ovary of the flower. - Seed with one cotyledon (monocots) - Seed with two cotyledons (dicots)	 Monocots (Maize)  Dicots (Mango)

1.3.5 Kingdom Animalia

Animals are multicellular and heterotrophic organisms. Animals are divided into two main groups: those that do not have a backbone (vertebral column) are grouped as invertebrates and those that have a backbone are grouped as vertebrates. Invertebrates make up more than 95 percent of all animal species alive today (Table 1.5 and 1.6).

Table 1.5 Major phyla of invertebrates

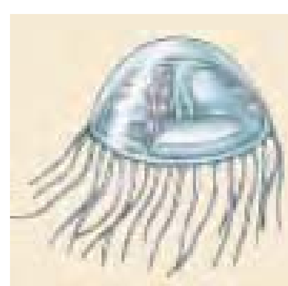
Phyla	Characteristics	Examples
Porifera	- Asymmetrical - Pore-filter feeders - Not motile (sessile) - Consists of two cell layers only; ectoderm and endoderm with mesoglea (non-cellular layer) between them (e.g., sponges)	 Sponge
Cnidaria	- Radial symmetry - Two cell layers only; ectoderm and endoderm with mesoglea between them - Body plan is with sessile polyp (vase-shaped) or motile medusa (inverted bowl-shaped). - Gastrovascular cavity present - All have stinging cells (e.g., corals, jellyfish)	 Jellyfish

Table 1.5 Major phyla of invertebrates (continued)

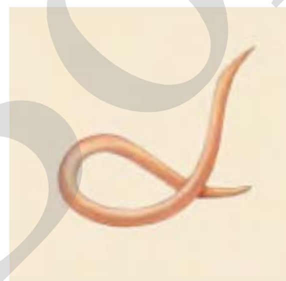
Phyla	Characteristics	Examples
Platyhelminthes	- Bilateral symmetry - Cephalization with head and brain - Three distinct cell layers (ectoderm, mesoderm and endoderm) - Acoelomate (no body cavity) - Incomplete digestive system (one opening) - Some are parasitic and others free living (e.g., tapeworm, flatworm)	 Tapeworm
Nematoda	- Bilateral symmetry - Cephalization with head and brain - Three distinct cell layers (ectoderm, mesoderm and endoderm) - Pseudocoelomate - Complete digestive system with separate mouth and anus (2 openings) - Many are parasitic (e.g., roundworms)	 Roundworm
Annelida	- Bilateral symmetry and segmented - Cephalization with head and brain - Three distinct cell layers (ectoderm, mesoderm and endoderm) - True coelom present, coelomate (e.g., earthworms, leeches)	 Earthworm
Mollusca	- Bilateral symmetry - Three distinct cell layers (ectoderm, mesoderm and endoderm) - Have soft body with or without shell (e.g., snails, slugs, clams, mussels, scallops, oysters, octopuses, squids)	 Snail

Table 1.5 Major phyla of invertebrates (continued)

Phyla	Characteristics	Examples
Arthropoda	- Bilateral symmetry with jointed appendages - Three distinct cell layers (ectoderm, mesoderm and endoderm) - Exoskeleton present (e.g., insects, spiders and scorpions, shellfishes (crustaceans), centipedes (one pair of leg per segment), millipedes (two pairs of leg per segment)	 Insect
Echinodermata	- Bilateral symmetry in embryo and radial symmetry in adult - Three distinct cell layers (ectoderm, mesoderm and endoderm) - Water vascular system present - Tube feet present on arms (e.g., starfishes, sea urchins, sea cucumbers)	 Starfish

Phylum Chordata (Vertebrata)

All the chordates have bilateral symmetry with three cell layers (ectoderm, mesoderm and endoderm) and dorsal hollow nerve cord. In addition, they all have notochord, pharyngeal gill slits and tail in embryo or in adults. The body of most of the vertebrates is divided into head, trunk and tail (Table 1.6).

Table 1.6 Major groups of vertebrates

Groups	Characteristics	Examples
Fish	- Vertebrates with scaly skin, except a few are scaleless - Live in water - Have gills - Have fins for swimming - Poikilothermic (e.g., bony and cartilaginous fish)	 Fish

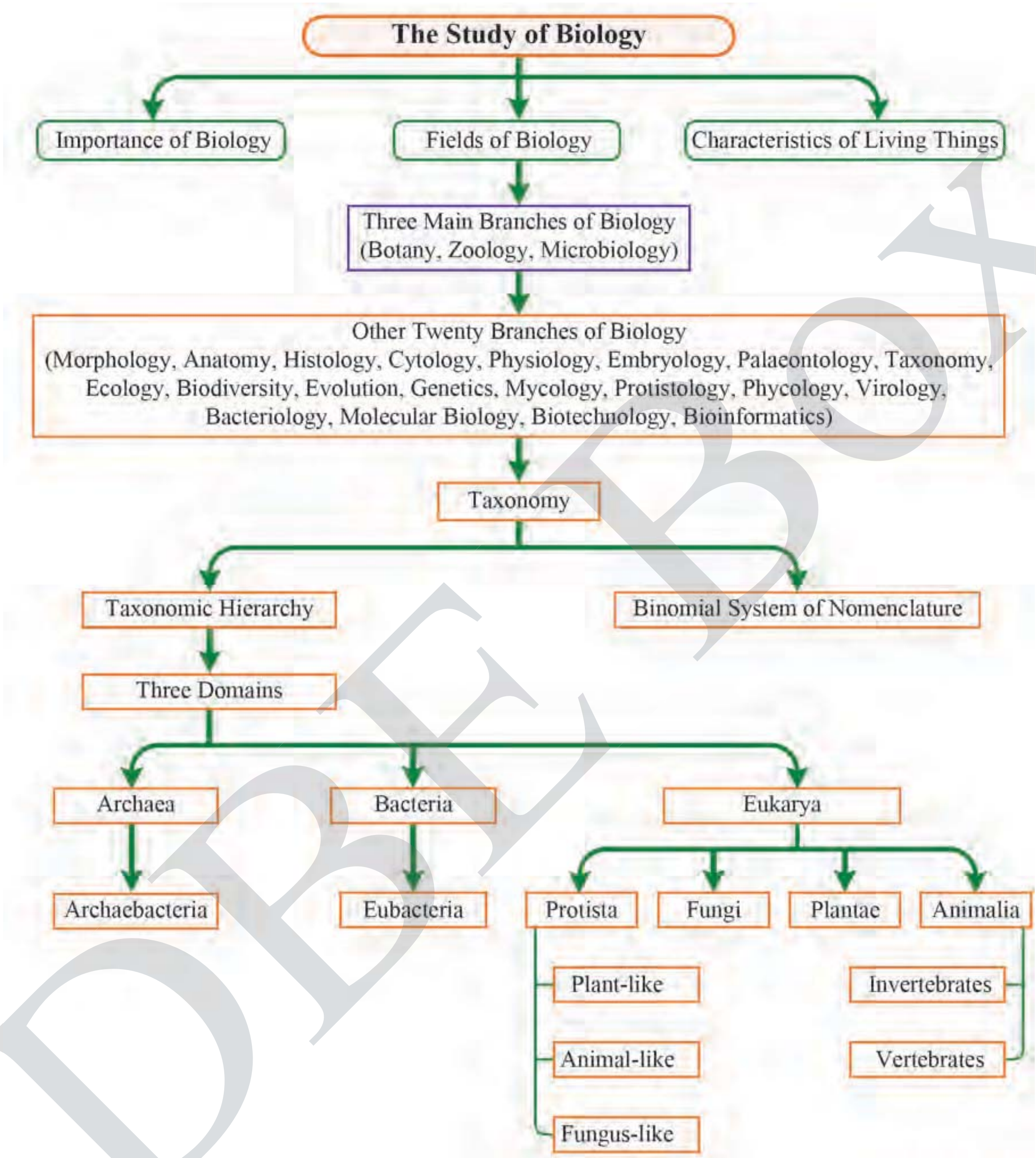
Table 1.6 Major groups of vertebrates (continued)

Groups	Characteristics	Examples
Amphibians	- Vertebrates with moist, scaleless skin - Larva has gills and adult has lungs. - Poikilothermic - Eggs laid in water, larva (tadpole) lives in water which metamorphoses into adult. - Adult often lives on land (e.g., frogs, newts and salamanders).	 Frog
Reptiles	- Vertebrates with scaly skin, some limbless - Lungs present - Poikilothermic - Lay eggs with shells (e.g., lizards, snakes, turtles)	 Snake
Birds	- Vertebrates with feathers and beak - Forelimbs have become wings for flight. - Lungs present - Homoiothermic - Lay eggs with hard shells (e.g., birds)	 Bird
Mammals	- Vertebrates with hair - Have different types of teeth (incisors, canines, premolars and molars) - Have lungs and diaphragm - Homoiothermic - Have a placenta and young feed on milk from mammary glands (e.g., cats, dogs, humans)	 Wild cat

Review questions

1. What are the main branches of biology?
2. State the different fields of biology and their definitions.
3. Explain the term taxonomy in your own words.
4. Define the term biodiversity.
5. Why are living organisms grouped into domains, kingdoms and lower category hierarchies?
6. Briefly explain what is meant by the Binomial System of Nomenclature.
7. Write down the names of the three domains and the six kingdoms.
8. Distinguish eubacteria from archaebacteria citing major differences and similarities.
9. Explain how living things have been separated into six kingdoms.
10. Explain why Protists could be considered as animals.
11. Explain why Protista are classified separately from Animalia.
12. Can heterotrophic Protists be placed under a single phylum? Explain your reasoning.
13. State the characteristics of Fungi.
14. What are the characteristics of Bryophyta with examples?
15. Describe the nature of flowering plants.
16. Describe the characteristics that allow nematodes to be distinguished from platyhelminth worms.
17. Where can you find metamorphosis among the vertebrates? Give examples.

Concept map


The Study of Biology
Importance of Biology
Fields of Biology
Characteristics of Living Things
Three Main Branches of Biology (Botany, Zoology, Microbiology)
Other Twenty Branches of Biology (Morphology, Anatomy, Histology, Cytology, Physiology, Embryology, Palaeontology, Taxonomy, Ecology, Biodiversity, Evolution, Genetics, Mycology, Protistology, Phycology, Virology, Bacteriology, Molecular Biology, Biotechnology, Bioinformatics)
Taxonomy
Taxonomic Hierarchy
Binomial System of Nomenclature
Three Domains
Archaea
Bacteria
Eukarya
Archaebacteria
Eubacteria
Protista
Fungi
Plantae
Animalia
Plant-like
Animal-like
Fungus-like
Invertebrates
Vertebrates

CHAPTER 2
CELL STRUCTURE AND ORGANIZATION

Learning Outcomes

It is expected that students will

- distinguish between the prokaryotic and eukaryotic cells by reviewing their common characteristics, roles and functions
- examine cellular components and describe their characteristics and functions
- study how cells are organized into tissues, organs and organ systems

2.1 CELLS AS THE BUILDING BLOCKS OF LIFE

All living organisms are composed of basic functional units called cells. The simplest organisms are made up of the single cells which perform all the functions of life. The complex organisms are composed of millions of cells. In multicellular (many-celled) organisms, there may be hundreds of different types of cells with different structures. They are specialized to carry out particular functions in plants or animals.

Cells are made up of a number of different subunits called organelles. These subunits are often of a particular size but all are microscopically small. So that a microscope with a high magnification and resolution is needed to observe cells and their subunits.

2.1.1 The Cell Theory

The basic principles of the cell theory are:

1. Cells are the building blocks or basic structures in all living things.
2. Cells are the smallest units of living things, they are the basic units of organization of all organisms.
3. All cells are derived from other cells (pre-existing cells) by means of division.
4. Cells contain a blueprint (i.e. information) outlining their growth, development and function.
5. Within cells, there are sites and structures where the chemical reactions of life occur (metabolism).

2.1.2 Prokaryotic and Eukaryotic Cells

Both types of cells are bounded by the plasma membrane which is semipermeable. Inside the cells is a semifluid jelly-like substance called cytoplasm, in which cellular organelles are suspended. All cells contain chromosomes which carry genes in the form of DNA. All cells have ribosomes, tiny organelles that make proteins according to instructions from the genes.

The cells of bacteria and archaea are prokaryotic (Figure 2.1) while those of protists, fungi, plants and animals are eukaryotic (Figure 2.2 and 2.3). Prokaryotic cells evolved before eukaryotic cells and they lack a true nucleus. A membrane bounds the nuclear materials of a true nucleus. Eukaryotic cell possesses a true nucleus. Prokaryotic cell possesses nuclear materials but lacks a nuclear membrane. Prokaryotic cells are 0.1 - 5.0 μm in diameter while eukaryotic cells are typically 10 - 100 μm in diameter.

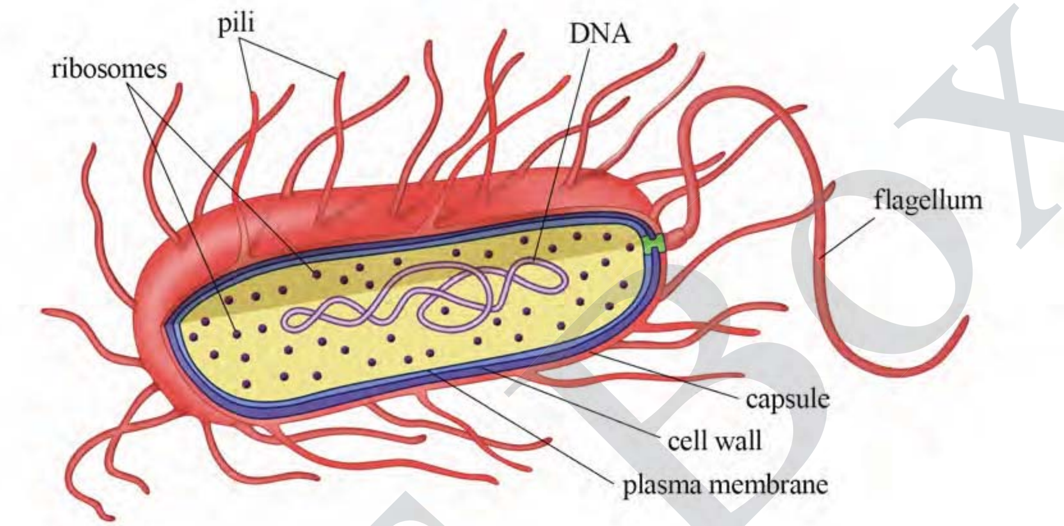


Figure 2.1 Prokaryotic cell: a rod-shaped bacterium

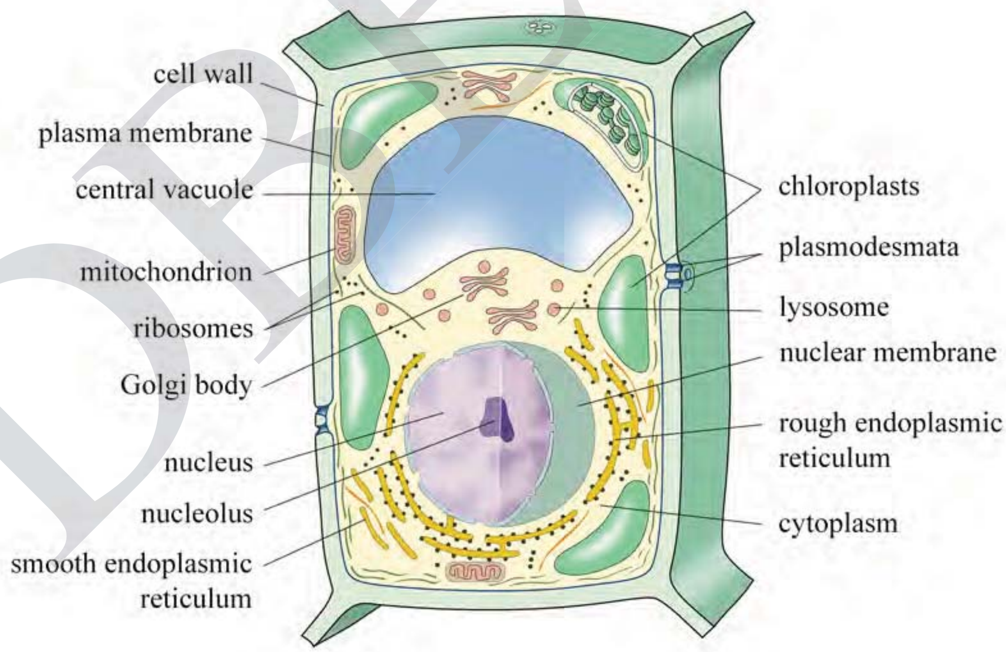


Figure 2.2 Eukaryotic cell: a plant cell

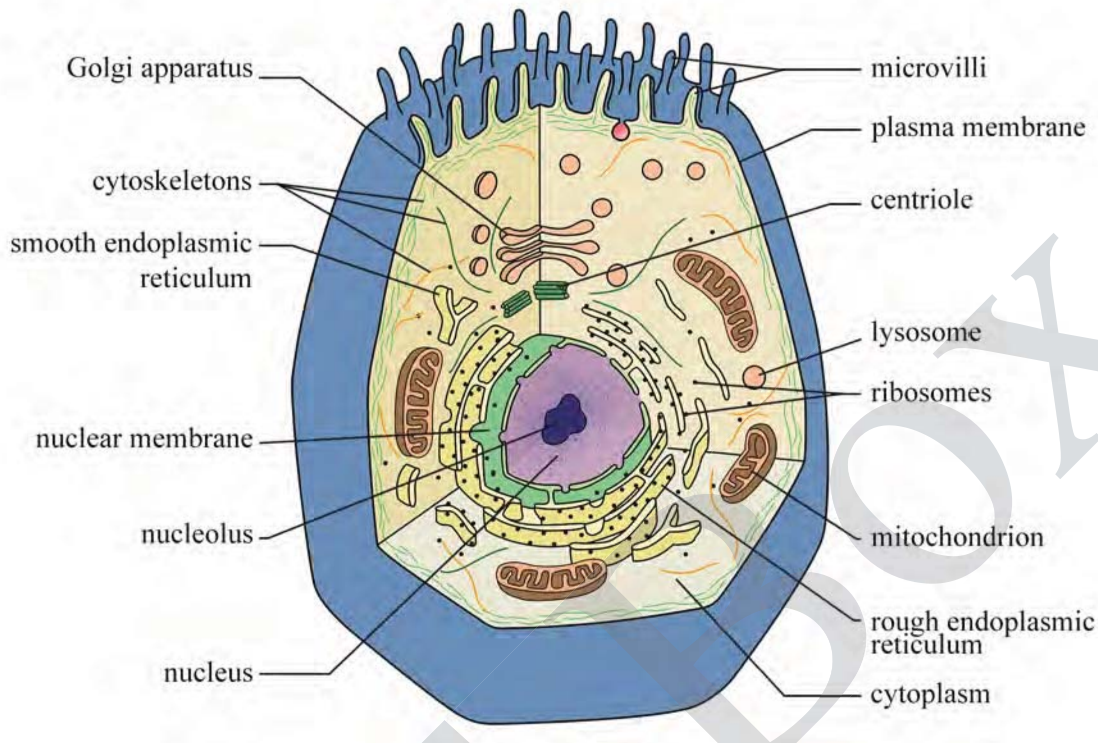


Figure 2.3 Eukaryotic cell: an animal cell

The major difference between prokaryotic and eukaryotic cells is the location of their DNA. In a eukaryotic cell, most of DNA is in the nucleus, which is bounded by a double membrane. In a prokaryotic cell, the DNA is concentrated in a region that is not membrane bound called the nucleoid, which is part of cytoplasm. The DNA of prokaryotic cell is circular and contains only nucleic acid with no proteins while that of eukaryotic cells is linear and made up of nucleic acid and the proteins called **histones**.

Membrane bounded organelles are present in eukaryotic cell, whereas membrane bounded organelles are not present in prokaryotic cell. In eukaryotes, cell walls are absent except in plants and fungi. In prokaryotes, cell walls are present (Table 2.1).

Table 2.1 Comparison between the structure of prokaryotic and eukaryotic cells

Prokaryotic cell	Eukaryotic cell
- Average diameter is 0.1 - 5 µm.	- Average diameter is 10 - 100 µm.
- Single copy DNA present and it is circular and contains only nucleic acid with no proteins.	- Multiple copies DNA present - They are linear and made up of nucleic acid and proteins.
- DNA is located in the cytoplasm.	- DNA is located in the nucleus, chloroplasts and mitochondria.
- Nucleus absent	- Nucleus present
- Ribosomes are about 20 nm in size.	- Ribosomes are about 25 nm in size.
- No membrane bounded organelles	- Membrane bounded organelles present
- Cell wall present which is made up of murein, a peptidoglycan	- Cell wall present in plants and fungi only - In plants, it is made up of cellulose or lignin while in fungi, it is made up of chitin. Cell wall absent in animal cell.

2.2 EUKARYOTIC CELL STRUCTURE

Plant and animal cells have common features which include a **plasma membrane** (cell membrane), a **nucleus** and **cytoplasm**. Not all the ultrastructures of a cell are seen with a light microscope.

2.2.1 Differences in Cell Structure

Cells of different organisms and even cells within the same organisms are very diverse in terms of shape, size, internal organization and function. One theme that occurs repeatedly throughout biology is that form follows function. In other words, a cell's function influences its physical features. The diversity in cell shape and structure reflects the different functions of cells.

2.2.2 Cell Components

Most plant and animal cells contain certain parts such as the nucleus, cytoplasm and cell membrane. But other cell components may be present or absent in plant and animal cells (Table 2.2).

Table 2.2 Summarized account of the components found in plant and animal cells

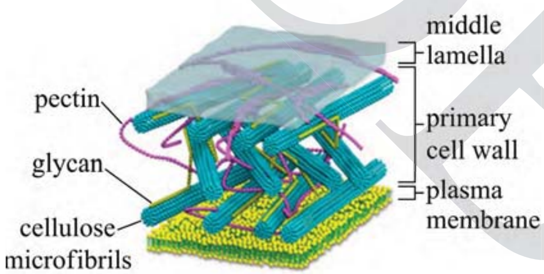
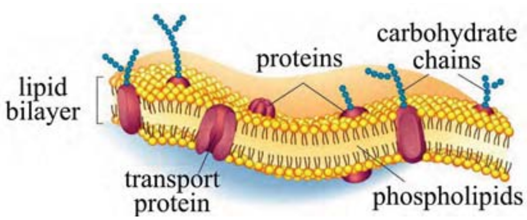
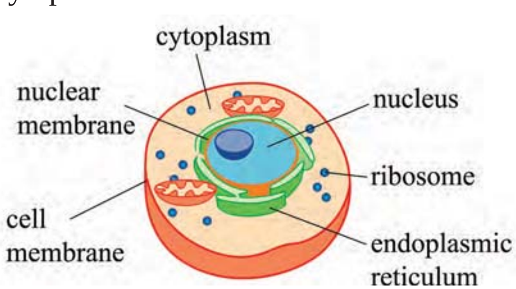
Names of components	Locations	Structures	Functions	Plant cell	Animal cell
Cell wall 	- Outside the cell membrane	- A structural layer surrounding some types of cells, just outside the cell membrane	- Give the cell strength and structure, and to filter molecules that pass in and out of the cell	Present	Absent
Cell membrane (Plasma membrane) 	- Around the cytoplasm	- Phospholipid bilayer with proteins attached to or embedded in it	- Surround the cell - Act as partially permeable membrane	Present	Present
Cytoplasm 	- Outside of the nucleus and within the cell membrane	- Jelly like structure, in which organelles are embedded	- Act as a site for chemical reactions to take place - Hold the organelles	Present	Present

Table 2.2 Summarized account of the components found in plant and animal cells (continued)

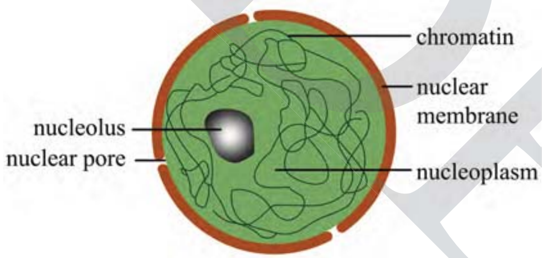
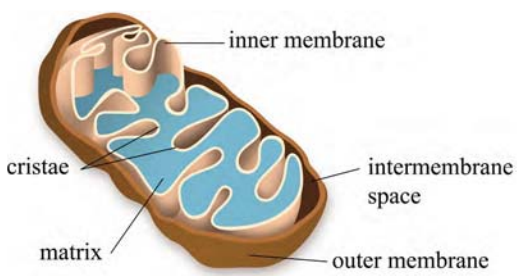
Names of components	Locations	Structures	Functions	Plant cell	Animal cell
Nucleus 	- Inside the cytoplasm	- A circular (or) oval structure	- Control the cell's activities	Present	Present
Mitochondrion 	- Inside the cytoplasm	- Rod (or) spherical shape	- Aerobic respiration - Acts as a site for synthesis of lipids - Generate ATP as energy molecules	Present	Present

Table 2.2 Summarized account of the components found in plant and animal cells (continued)

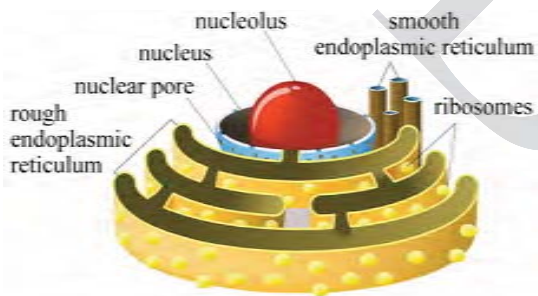
Names of components	Locations	Structures	Functions	Plant cell	Animal cell
Endoplasmic reticulum (ER) (Smooth ER, Rough ER)  	- Inside the cytoplasm	- A network of tubules and flattened sacs - Smooth ER; its outer surface lacks ribosomes - Rough ER is studded with ribosomes on the outer surface of its membrane	- Continuous with the outer membrane of the nuclear envelope - Smooth ER: synthesis of lipids, metabolism of carbohydrates, calcium storage, detoxification of drugs and poisons - Rough ER: aids in synthesis of secretory and other proteins on bound ribosomes; adds carbohydrates to proteins to make glycoproteins; produces new membrane	Present	Present

Table 2.2 Summarized account of the components found in plant and animal cells (continued)

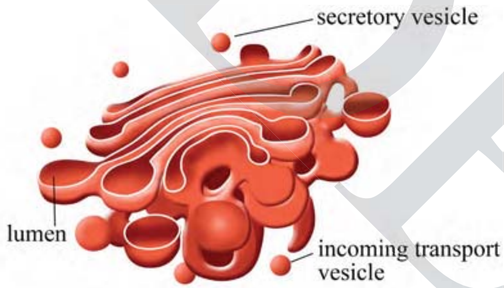
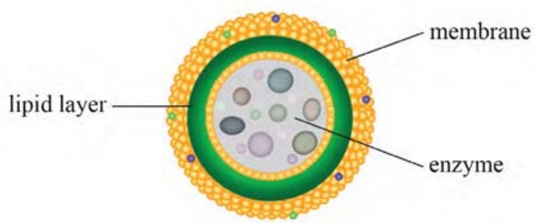
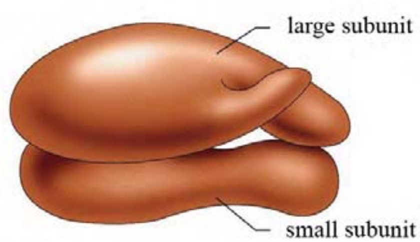
Names of components	Locations	Structures	Functions	Plant cell	Animal cell
Golgi apparatus 	- Located very near the rough endoplasmic reticulum and hence near the nucleus	- A stack of flattened sacs	- Collect, process and sorts molecules - Convert sugars into cell wall components - Make lysosomes	Present	Present
Lysosome 	- Inside the cytoplasm	- Spherical sacs - Surrounded by a single membrane and having no internal structure	- Breakdown (digestion) the unwanted structures such as old organelles or even whole cells	Present	Present
Ribosome 	- Some are attached to rough endoplasmic reticulum - Some are free in cytoplasm	- Tiny organelle - Has two subunits	- Protein synthesis	Present	Present

Table 2.2 Summarized account of the components found in plant and animal cells (continued)

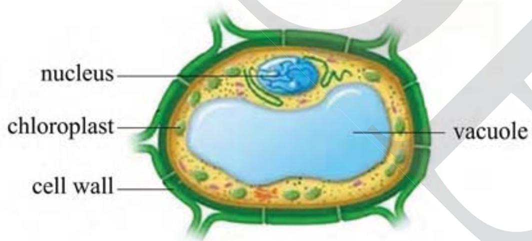
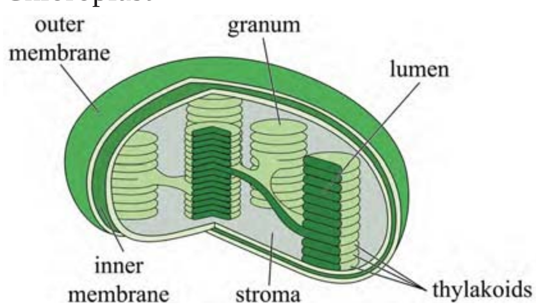
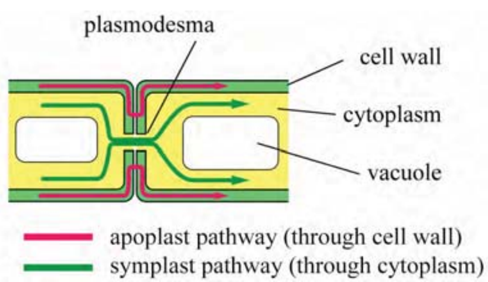
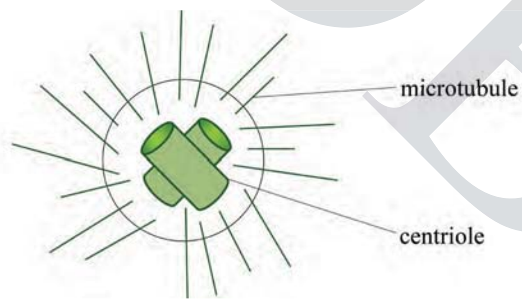
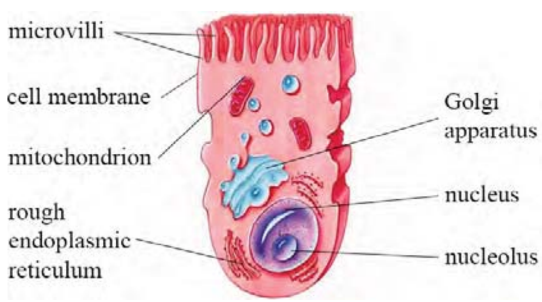
Names of components	Locations	Structures	Functions	Plant cell	Animal cell
Vacuole 	- Inside a cell	- A fluid-filled space enclosed by a membrane	- Control exchange between the vacuole and the cytoplasm, regulate the osmotic properties of cells	Present	Present
Chloroplast 	- Present in the leaves	- Large organelle	- Photosynthesis - Generate chemical energy as glucose molecules	Present	Absent
Plasmodesmata 	- Only in plant and algal cells	- Fine strands of cytoplasm - Pass through pore-like structures	- Connects the internal chemical environment of adjacent cells - Allows water and small solutes to pass freely from cell to cell	Present	Absent

Table 2.2 Summarized account of the components found in plant and animal cells (continued)

Names of components	Locations	Structures	Functions	Plant cell	Animal cell
Centrosome and centrioles 	- Near the nucleus	- Within the centrosome is a pair of centrioles - Each composed of nine sets of triplet microtubules arranged in a ring	- Grow spindle microtubules for nuclear division	Absent	Present
Microvilli 	- Located on cell surface	- Finger-like extensions	- Absorption (in the gut), reabsorption (in the kidney)	Absent	Present

2.2.3 Cell Organization

Atoms are organized into molecules, molecules into organelles and organelles into cells. Cells are divided into several compartments called organelles, each with a characteristic structure, biochemical composition and function. The cell must possess enough information to specify which molecules are to be associated in a specific compartment. It is ensured to route the appropriate groups of molecules to their compartments. According to the cell theory, all living things are composed of one or more cells as unicellular and multicellular organisms.

In unicellular organisms, the single cell performs all life functions independently. In multicellular organisms, various levels of organization are present. They are made up of more than one type of cells and have specialized cells that are grouped together to carry out specialized functions. Individual cells may perform specific functions and also work together for the survival of the entire organism. The cells become dependent on one another. There are five levels of organization in multicellular organisms: cells, tissues, organs, organ systems and organisms.

Cells are the simplest level of organization. Specialized cells show division of labour by being grouped into tissues; the tissues may be further grouped into organs and the organs into systems. Each tissue, organ or system has a particular function and a structure appropriate to that function.

Tissues

A **tissue** is a group of cells with similar structures, working together to perform a particular function. In each tissue, the cells are alike, with the same characteristics of size, form and arrangement. They are specialized or differentiated both structurally and physiologically to perform some particular functions.

(A) Plant tissues

Plant tissues deal with the study of internal structure of various parts of the plant like root, stem and leaf. All these parts are made up of different kinds of tissues. The cells of a tissue generally have a common origin. In the higher plants, tissues show a division of labour and form three basic tissue systems in plants (Figure 2.4).

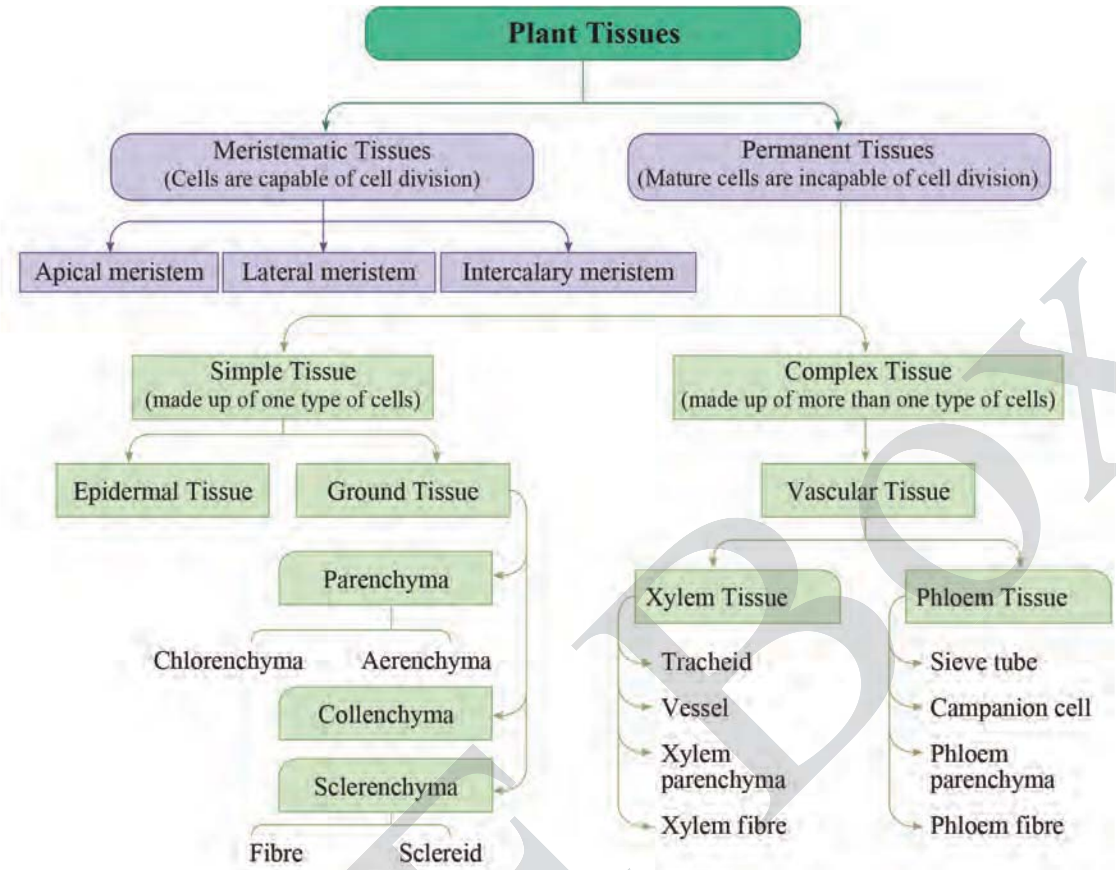


Figure 2.4 Types of tissue system in plant

Level of organization in plants

The plant body of most vascular plants is constructed from millions of tiny cells. They have characteristic shapes and functions and are grouped together to form tissues. Various types of tissues are grouped together into a structural and functional unit called an organ. The organs that perform major activity together are formed as a system.

Organs

1. Plant organs include roots, stems, leaves and flowers which consist of tissues.
2. There are less organs in plants as compared to animals.

Organ systems

1. The plant body consists of two main systems:

(a) The root system (underground part) - is composed of main roots and branches. These organs are formed as the absorptive system; absorb water and mineral salts from the soil.

(b) The shoot system (above ground part) - is composed of stems, leaves, buds, flowers and fruits. The stem acts as a support system and the flower performs as a reproductive system.

Root system and shoot system work together as a plant.

(B) Animal tissues

Animal tissues can be classified into four basic groups: (1) **epithelial or covering** (2) **connective or supporting** (3) **muscle or contractile** and (4) **nervous**. Each tissue type is assembled from individual cells that determine the structure and the function of the tissue. The structure and integrity of a tissue depend on the structure and organization of the cytoskeleton within the cells, the type and organization of the extracellular matrix (ECM) surrounding the cell and the junctions holding cells together (Figure 2.5).

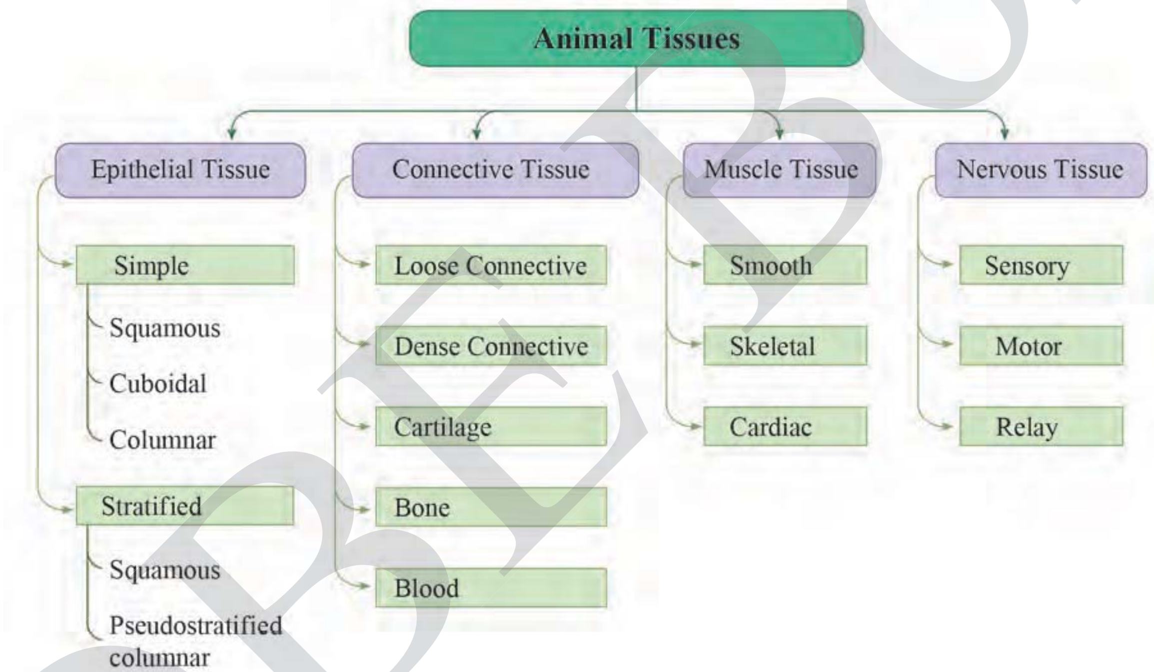


Figure 2.5 Types of tissue system in animal

Organs

Organs are body structures composed of several different types of tissues that form a structural and functional unit. One example is the heart which contains cardiac muscle, connective tissue and epithelial tissue and is laced with nerve tissue that helps to regulate the heartbeat.

Organ systems

An organ system is a group of organs that function together to carry out the major activities of the body. For example the seven main systems in the human body are given below.

(1) Digestive system - the digestive system is composed of the digestive tract, liver, gall bladder and pancreas. These organs cooperate in the digestion of food and the absorption of digested products into the body

(2) Gas exchange system - including the lungs which exchange oxygen and carbon dioxide

(3) Circulatory system - including the heart and blood vessels which transport materials around the body

(4) Excretory system - including the kidneys which filter toxic waste materials from the blood

(5) Nervous system - consisting of the brain, spinal cord and nerves which coordinate the body's actions

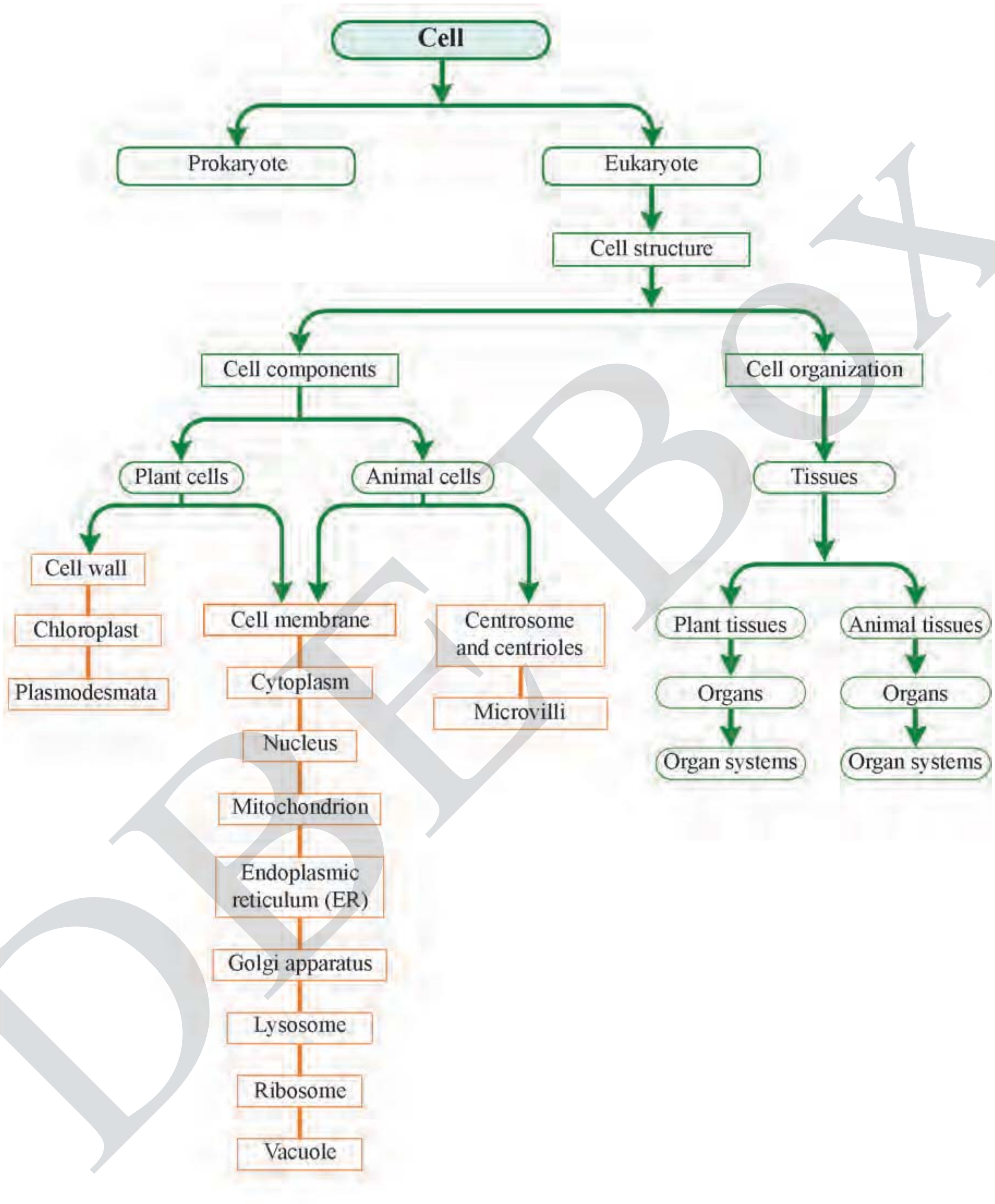
(6) Endocrine system - glands secreting hormones which act as chemical messengers

(7) Reproductive system - producing male and female gametes, respectively and allowing the development of the embryo

Review questions

1. Define the basic principles of cell theory.
2. What are the features that are common to cells in all living things?
3. State the differences of DNA between prokaryote and eukaryote.
4. Compare and contrast the structures of cells with and without a nuclear membrane.
5. What are the functions of plant cell wall?
6. Energy is essential in cells. Which organelles of a cell generate energy to support cell activities?
7. Mention the levels of cell organization in multicellular organism such as human being.
8. Which components of the cell control the cell activities?
9. Define the terms tissue, organ and system.
10. Differentiate plant tissues with a relevant flow chart.
11. Identify the basic tissue groups found in animals.
12. Which organ systems are responsible for
    (a) gaseous exchange
    (b) filtering toxic waste materials
    (c) coordination of the body's actions

Concept map


Cell
Prokaryote
Eukaryote
Cell structure
Cell components
Cell organization
Plant cells
Animal cells
Tissues
Cell wall
Chloroplast
Plasmodesmata
Cell membrane
Cytoplasm
Nucleus
Mitochondrion
Endoplasmic reticulum (ER)
Golgi apparatus
Lysosome
Ribosome
Vacuole
Centrosome and centrioles
Microvilli
Plant tissues
Animal tissues
Organs
Organs
Organ systems
Organ systems

CHAPTER 3
SUPPORT AND LOCOMOTION

Learning Outcomes

It is expected that students will

- identify the different types of support and locomotion systems in living organisms and can describe each function
- investigate the importance of maintaining a healthy musculoskeletal system

3.1 SUPPORT SYSTEMS

The support system is very important to all living things such as plants, animals and humans.

Plants do not have skeletons like animals but they use their turgidity of cells within packing tissue and the strongly constructed conducting tissue for support.

In humans and other animals, the main body support is provided by the internal skeletal system of bones in association with cartilage and the muscular system. In some animals, the skeleton is external as in insects and prawns. In all animals and humans, the skeleton supports body weight, maintains body shape, protects soft organs inside the body, provides place for muscle attachment and enables movement.

3.1.1 Support Systems in Aquatic Plants

Aquatic plants cannot stay upright on land because of their stems which are soft and non-woody. But aquatic plants can stay upright in water because their weights are supported by the buoyancy of water. Some aquatic plants have many air sacs in their leaves and stems that make them light so that they can float on water. Some aquatic plants have tiny leaves to ensure that they are not disrupted by the flow of water, e.g., *Hydrilla*. Aquatic plants may be distinguished into three groups: (1) submerged plants (2) floating plants and (3) emergent plants.

(1) Submerged plants

They are rooted in the bottom of a water course and the leaves remain submerged below the surface of the water. Numerous air sacs inside the leaves and stems keep the plant floating close to the surface to obtain maximum sunlight. e.g., *Vallisneria* (Nga-shint-myet) (Figure 3.1)

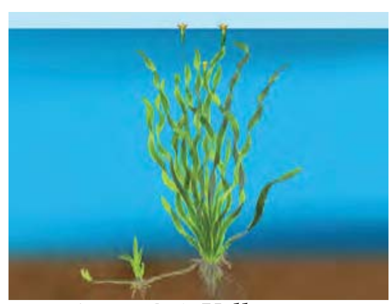


Figure 3.1 *Vallisneria*

(2) Floating plants

(a) Free floating plants

These plants float freely on the water surface. In free floating plants, the petioles are swollen and spongy, consisting of numerous air spaces. The presence of these air spaces makes the plants lighter and enables them to float on water. e.g., water hyacinth (Beda) (Figure 3.2)

Figure 3.2 Water hyacinth

(b) Submerged floating plants

These plants anchor to the bottom of the pond by roots but their leaves and flowers float on the water surface. The aerenchyma tissues (spongy and air spaces) in the stems and leaves make the plants float on the surface of the water. e.g., water lily (Kya) (Figure 3.3)

Figure 3.3 Water lily

(c) Trailing floating plants

These plants have long and horizontal stems (stolon). These stems are hollow and can float easily. e.g., buffalo spinach (Kana-hpaw) (Figure 3.4)

Figure 3.4 Buffalo spinach

(3) Emergent plants

The plant consists of tufts of basal leaves which rise from the spreading rhizomes. The leaves are erect, sword-shaped, flat and have parallel veins. e.g., sweet flag (Linn-nay) (Figure 3.5)

Figure 3.5 Sweet flag

3.1.2 Support Systems in Terrestrial Plants

The plant has various methods and systems for support to maintain its shape and for its protection. The types of support are physiological and structural. The physiological support is a temporary support because it depends on the presence of water in the plant cells. There is no support if the water in the plant cells is lost.

(a) The physiological support

Physiological support affects the cell itself as a whole. The water enters the vacuole of the cell by osmosis. An internal pressure is built up inside the cell vacuole, called turgor pressure. The pressure pushes the plasma membrane against the cell wall, causing the cell to swell. The cell becomes turgid to get the support (Figure 3.6).

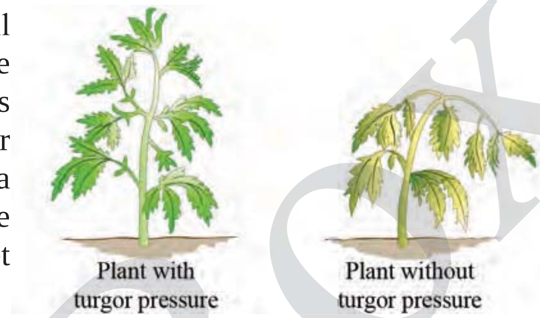


Figure 3.6 The physiological support

(b) The structural support

The structural support is a permanent support. Various structural support systems include woody plants: trees and shrubs, non-woody plants: herbaceous plants and climbers.

Support in woody plants

Support in woody plants has specialized tissue to give them support. The tissue has cellulose cell wall, having lignification for added strength. Tissues with such walls are sclerenchyma tissues, e.g., xylems, vessels and tracheids (Figure 3.7).

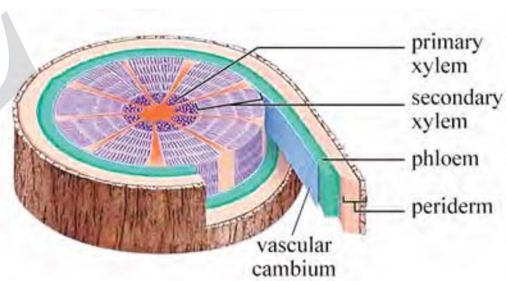


Figure 3.7 Woody stem

Support in non-woody plants

Support in non-woody plants (herbaceous and climbers) depends on the turgidity of their cells such as parenchyma, collenchyma and other supportive tissues to give support. Climbers have modifications for climbing up a support in order to obtain sunlight (Figure 3.8).

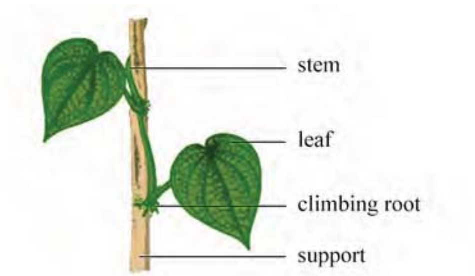


Figure 3.8 Climbing roots of betel

(c) Special support structures

Prop roots

Roots which grow down from the stem or branches into the ground for support. e.g., banyan tree (Nyaung-pin), maize (Pyaung) (Figure 3.9)

Figure 3.9 Prop roots

Tendrils

Curly string-like structures modified from the stems and leaves curl and twine around the parts of other plants or objects to help the plant to climb. e.g., cucumber (Tha-khwar), bittergourd (Kyet-hin-khar) (Figure 3.10)

Figure 3.10 Tendrils

Thorns

Sharp modified branches that cannot be easily removed. Thorns act as hooks to hold onto the support. e.g., bougainvillea (Setku-pan), rattan (Kyein) (Figure 3.11)

Figure 3.11 Thorns

Prickles

An outgrowth of the epidermis can be easily removed from the stem. e.g., rose (Hnin-si) (Figure 3.12)

Figure 3.12 Prickles

Buttress roots

The thick support roots grow from the stem above the ground. These roots hold the tree firmly to the ground, giving it extra support. e.g., durian (Du-yin), casuarina (Pinle-kavee) (Figure 3.13)

Figure 3.13 Buttress roots

Clasping roots

Roots grip onto other plants or structures to get support. e.g., betel (Kun), pepper (Nga-yoke-kaung) (Figure 3.14)

Figure 3.14 Clasping roots

3.1.3 Support Systems in Animals

Skeletons serve as main support systems for animals. Zoologists commonly recognize three types of skeletal systems in animals: **hydrostatic skeleton**, **exoskeleton** and **endoskeleton**.

(a) **Hydrostatic skeletons** are found primarily in soft-bodied terrestrial invertebrates, such as earthworms and slugs and soft-bodied aquatic invertebrates such as jellyfish and squids. Fluid-filled body cavities in **coelom** give support by means of hydrostatic pressure on the body wall (Figure 3.15 a).

(b) An **exoskeleton** is a rigid, hard case that surrounds the body. Arthropods such as crustaceans and insects have exoskeletons made of the polysaccharide chitin (Figure 3.15 b). A chitinous exoskeleton resists bending and thus acts as the skeletal framework of the body; it also provides attachment sites for the muscles which lie inside the exoskeletal casing. But in order to grow, the animal must periodically **molt**, shedding the exoskeleton. A slightly larger new exoskeleton will be formed.

(c) **Endoskeletons** found in vertebrates, sponges and echinoderms are rigid internal skeletons that form the body's frame work and offer surfaces for muscle attachment for movement and locomotion. Vertebrates such as fish, frogs, snakes, birds and mammals including humans have internal **bones** forming an endoskeleton. Echinoderms such as sea urchins and sand dollars have **endoskeletons** of ossicles made of calcium carbonate. This calcium compound is different from that in bone which is based mainly on calcium phosphate (Figure 3.15 c).

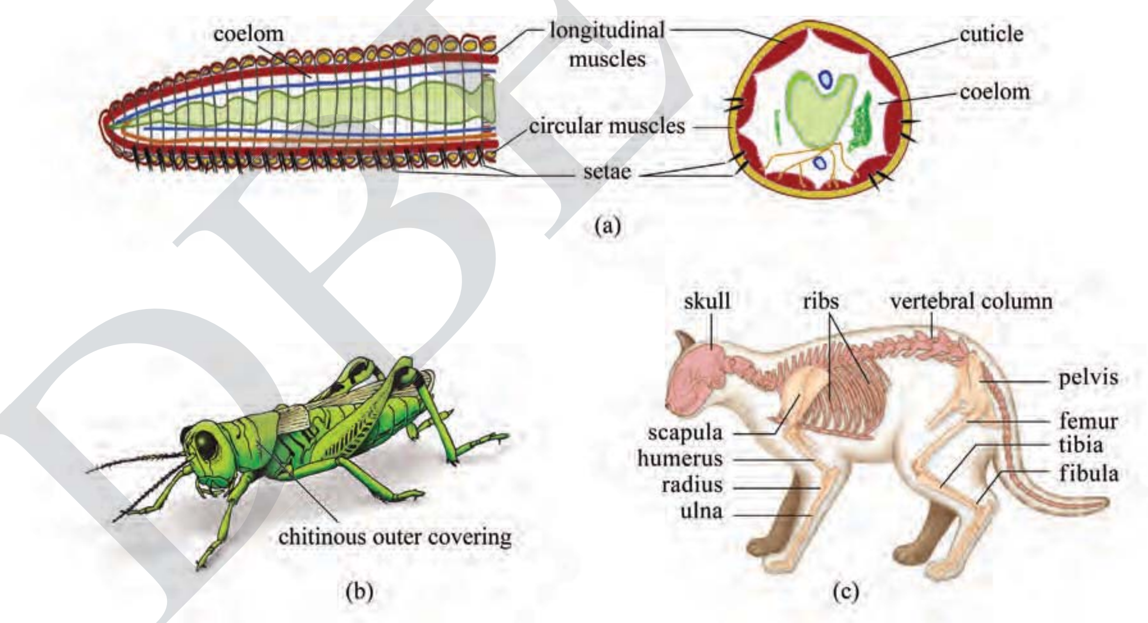


Figure 3.15 Skeletal systems of animals (a) Hydrostatic skeleton of earthworm (b) Exoskeleton of grasshopper (c) Endoskeleton of cat

3.1.4 Support System in Humans

The human skeleton has about 206 bones which can be categorized as part of either the **axial** or **appendicular** skeleton. The bones of the skeleton provide sites for muscle attachment, making movement possible particularly with jointed appendages.

The human endoskeletal system has many functions that contribute to homeostasis. The rigid endoskeleton supports the body. (1) The skeleton protects vital internal organs such as the brain, spinal cord, heart and lungs. (2) The bones of the skeleton provide sites for muscle attachment, making movement possible particularly with jointed appendages. (3) The skeleton serves as an important storage reservoir for ions such as calcium and phosphorus. (4) The skeleton produces blood cells within the red bone marrow of the skull, ribs, sternum, pelvis and long bones.

Axial skeleton

The axial skeleton is made up of the **bones** found in the trunk and head of the body. The bones of the axial skeleton support the weight of the body and protect the internal tissues. The axial skeleton includes the 27 bones in the **skull**, the 33 bones that form the **spine**, the 12 pairs of **ribs** and the **breast–bone** (sternum), the flat bone in the front of the chest that connects the ribs. Mandible or lower jaw bone is attached flexibly to the skull.

The bones of the axial skeleton cover most of the body's vital organs. **Vertebrae** are serially arranged bones of the spine that surround the spinal cord; there are cartilage discs between the vertebrae. Ligaments, holding the vertebrae together, permit a degree of movement in the spine. The bones of the **skull** are rigid and protect the brain but the lower jaw can move strongly in eating and speaking. The **ribs** and **sternum** protect the heart and lungs. Flexible tissues and muscles connecting the ribs allow the chest to expand and contract during breathing. Flexible tissues in the spine connecting vertebrae allow people to bend, turn and look behind.

Appendicular skeleton

The appendicular skeleton is the part of endoskeleton that is adapted to allow the body to move. It includes the bones in the **limbs** that extend from the trunk of the body such as legs, feet, arms and hands.

The appendicular skeleton also includes two sets of bones, called **girdles** that connect limbs to the axial skeleton of the body. The girdles attach the bones of the arms and legs to the body loosely enough that these limbs have a wide range of motion (Figure 3.16).

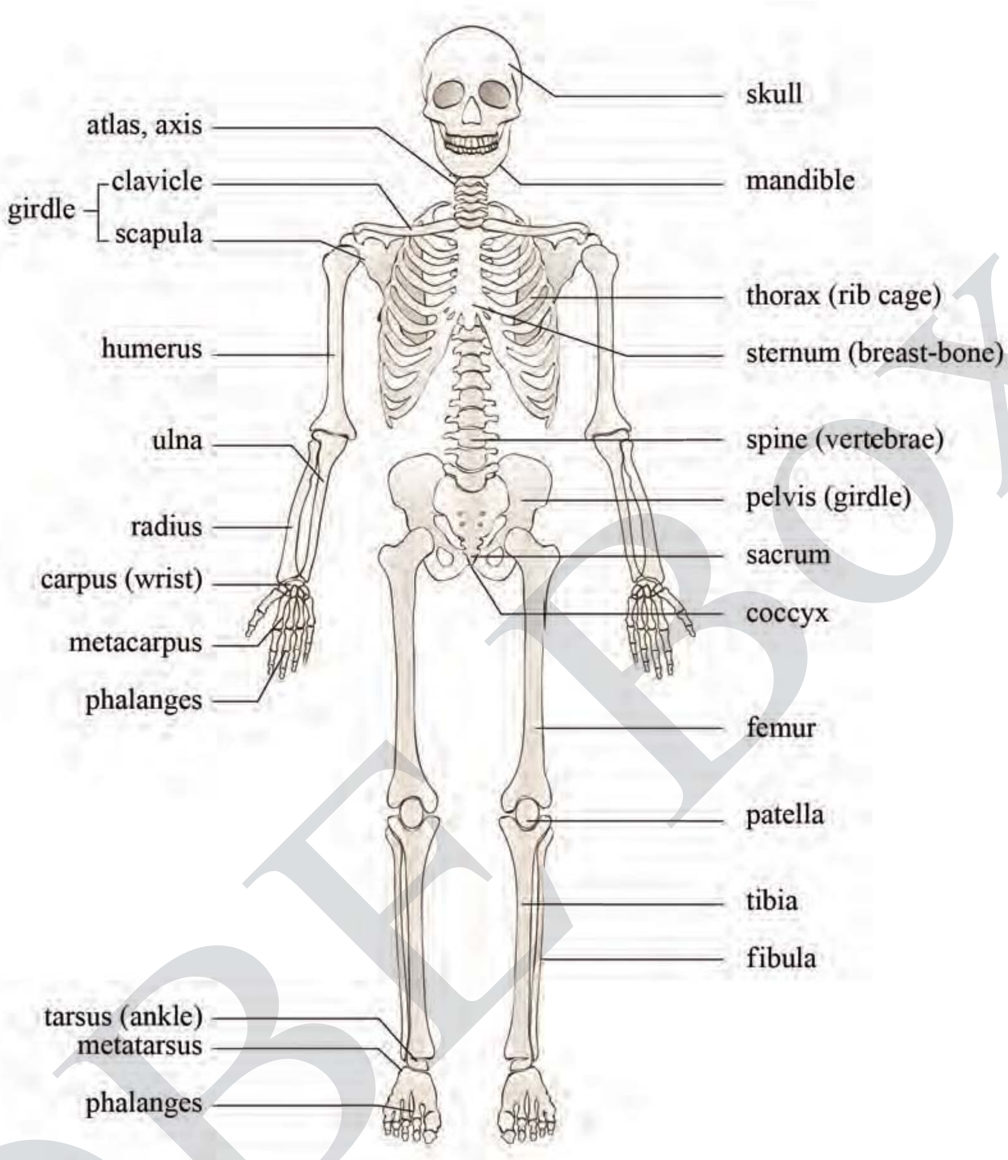


Figure 3.16 The human skeletal system

Bone

Bone tissue consists of a dense and hard organic matrix deposits of minerals (mainly calcium phosphate and some calcium carbonate) in between the bone cells. These cells remain alive and secrete the matrix throughout life. Most bones have a large cavity called marrow cavity in the centre. The marrow cavity may contain yellow marrow which is mainly fat or red marrow where blood cells are produced. **Haversian canals** running through the matrix of the bone consist of blood vessels and nerves for oxygen supply and control of the bone cells (Figure 3.17).

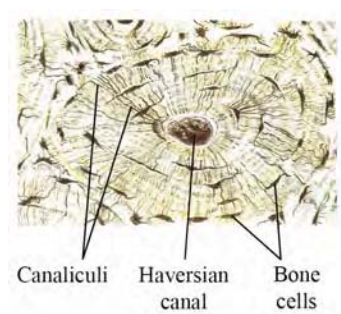


Figure 3.17 Microscopic structure of bone

Cartilage

f the two bones were in contact with one another, they would rub together every time they moved and eventually, the ends of the bones would wear down. But the ends of the bones are protected from wear by cartilage.

Cartilage is a flexible connective tissue that is found between the bones. It cushions the bones and allows for smooth movements. The cartilage found in the chest holds neighboring ribs together into one strong but flexible rib cage.

oints

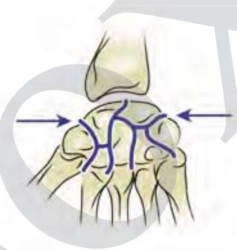
A joint is the place where two bones meet. Different types of joints allow for different amounts of bone movement. i rous oints are made of the same dense material that bone is made of and they act like a tough glue that connects the bones and holds them in place. Cartilaginous oints allow partial movement. n these joints, cartilage physically holds bone together.

ther joints called s no ial oints are cushioned with cartilage and held together by a capsule of ligaments. A liga ent is a long, flexible band of connective tissue that connects two bones across a joint. Synovial joints allow great degree of movement between bones. There are several different types of synovial joint which are listed below (Table 3.1).

Table 3.1 List of types of synovial joint in humans

oint types	ovements	Examples	llustrations
Hinge joint	- Flexion, extension	- lbow joint (shown), knee joint	
Ball and socket joint	- Flexion, extension, adduction, circumduction	- Shoulder joint (shown), hip joint	
Pivot joint	- Rotation	- Skull and atlas-axis and proximal radioulnar joint (shown)	

Table 3.1 ist of types of synovial joint in humans (continued)

oint types	ovements	xamples	llustrations
Saddle joint	- Flexion, extension, adduction, circumduction	- Base of thumb and carpals (shown)	
liding joint	- ne surface moves over another surface	- Between tarsal bones of ankle, between carpal bones (shown) of wrist	

The i portance o aintaining a health usculoskeletal s ste

The healthy musculoskeletal system allows for normal physical activities such as walking, running, jumping and other activities. Abnormal oints and uscles result in osteoarthritis in which damaged ends of bones rub against each other, causing joint pain and stiffness or the bones may become brittle and are more prone to fracture.

To maintain the musculoskeletal system the followings could be done.

(a) Stay active

Physical activities and exercises are necessary to maintain healthy joints between bones. These can also strengthen muscles that hold the joints.

(b) Do not overextend the joints

Some movements can cause injuries. Rapid direction changes and twisting can lead to joint damage involving cartilages and ligaments.

(c) at healthy food

Health of bones, joints and muscles can be supported by healthy food. Dark green vegetables, olive oil, citrus fruits, fish and poultry have nutrients for bone and muscle development. itamins C, K and A, iron, calcium, phosphorus and magnesium are good for joints. Proteins play a critical role in muscle and cartilage repair.

(d) Reduce weight and stay fit by exercising

Reducing body weight by exercising regularly reduces joint pain, improve joint health and keeps muscle strong.

T P TS

The plants are fixed at a place with their roots in the ground. Although they cannot move from one place to another by their bodies but they can move with their parts. These movements are caused due to response of plants to external stimuli such as light, water, gravity, chemicals, etc. Plants show two types of movements.

1. rowth-dependent movements called the tropic movements (towards or away from a stimulus) and
2. Non-growth dependent movements called the nastic movements (not dependent on the direction of stimulus)

Tropic o e ents

The movement of a plant in the direction of stimulus is known as tropic movement. Plant may either show a positive or negative movement as a response to a stimulus. f the movement is towards the direction of stimuli, it is known as positive tropism. f the movement is away from the stimuli, it is known as negative tropism. Tropic movements in plants can be classified into six types. These are:

(a) Phototropism
(b) eotropism
(c) Hydrotropism
(d) Chemotropism
(e) Thigmotropism and
(f) Thermotropism

(a) Phototropis

Plants are very sensitive to light. The movement of plants in response to light is known as phototropism. The shoot system of a plant shows positively phototropic whereas the root is negatively phototropic (Figure 3.1).

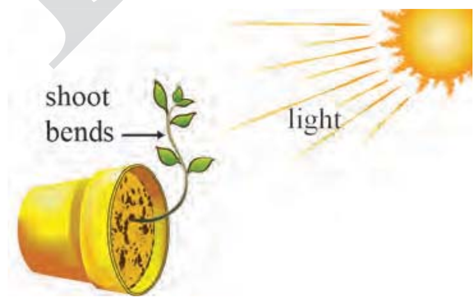


Figure 3.1 Phototropism

( ) eotropis

The movement of a plant part towards the soil in response to earth s gravity is known as geotropism. n geotropism, the shoot is negatively geotropic and the root is positively geotropic (Figure 3.19).

Figure 3.19 eotropism

(c) drotropis

The movement of the plant towards the water is known as hydrotropism. The stimulus here is water. Roots are positively hydrotropic (Figure 3.20).

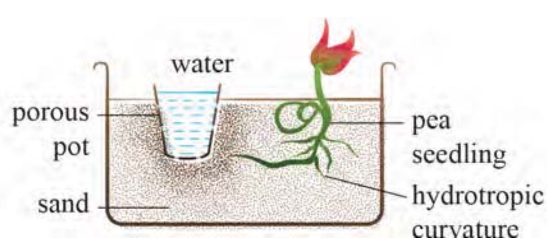


Figure 3.20 Hydrotropism

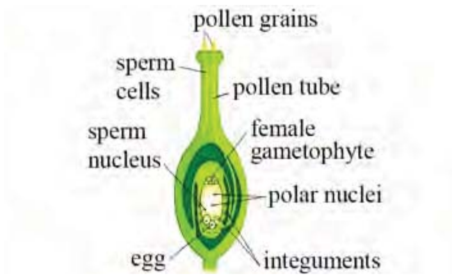


Figure 3.21 Chemotropism

(d) Che otropis

The movement of plants in response to a chemical stimulus is known as chemotropism. An example of this type of movement is the growth of pollen tube towards ovule during fertilization due to secretion of a sugary chemical in the ovary (Figure 3.21).

(e) Thig otropis

The directional movement in plants in response to touch is known as thigmotropism. e.g., the plant tendrils climb around any support which they touch (Figure 3.22).

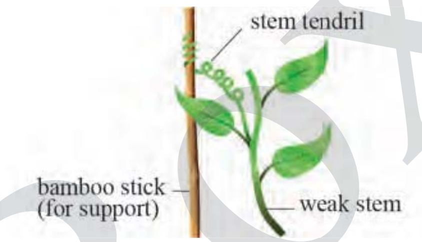


Figure 3.22 Thigmotropism

Figure 3.23 Thermotropism

( ) Ther otropis

Thermotropism is the movement of plant or their parts in response to changes in the external stimulus of temperature (Figure 3.23).

astic o e ents

Nastic movements in plants are not directional movements. They are not dependent on the direction of the stimulus. For example, the leaves of touch me not (*Mimosa*, Hti-ka-yone), fold up immediately when touched. These kinds of changes occur due to the changes in the amount of water in the leaves. Depending on the uantity of water, they either swell up or shrink (Figure 3.24). n other example, pitcher plant (*Nepenthes*, e-ta-gaung), the closing of the lid of insectivorous plant occurs due to the catchment of the insects (Figure 3.2).


Figure 3.24 *Mimosa*

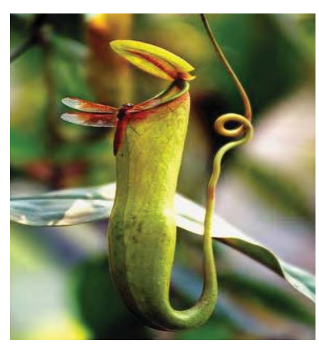


Figure 3.2 *Nepenthes*

T C T S S

The ability to move in animals is made possible by the combination of a semi rigid skeletal system with joints that act as hinges and a muscular system attached that can pull on this skeleton. uscular action produces a change in body shape, which places a force on different parts of the outside environment, for example, when a horse runs, its feet contact the ground, the force they exert moves its body forward rapidly. n a similar way, when a bird takes off into flight, its wings exert force on the air and a swimming fish movements push against the water. The nature of the muscular and skeletal systems allows movement in animals.

o e ent and oco otion in arious Si ple ni als

oco otion in earth or

n these animals a fluid-filled central body cavity or coelom is encompassed by two sets of muscles in the body wall circular uscles that are repeated in segments and run the length of the body and longitudinal uscles that oppose the action of the circular muscles. Short and bristle like structures called setae are on the underside of a worm s body.

Muscles act on the fluid in the body's central space which represents the h drostatic skeleton.

This locomotion process proceeds as waves of circular-muscle contraction that are followed by waves of longitudinal muscle contraction which pass backward.

Steps in earthworm locomotion are

1. n the anterior end, circular muscles contract and longitudinal muscles relax. Setae lose contact with ground.
2. The front end of the body extends forward.
3. Next, the circular muscles contract the longitudinal muscles relax. Anterior of the body swells and setae anchor the ground.
4. Body region behind the anterior end is pulled forward. Setae prevent slipping backward of the front end (Figure 3.2).

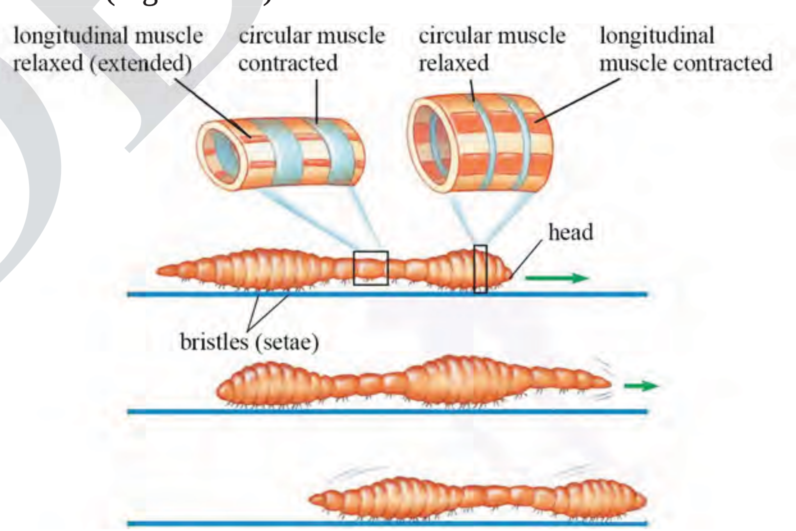


Figure 3.2 ocomotion in earthworm

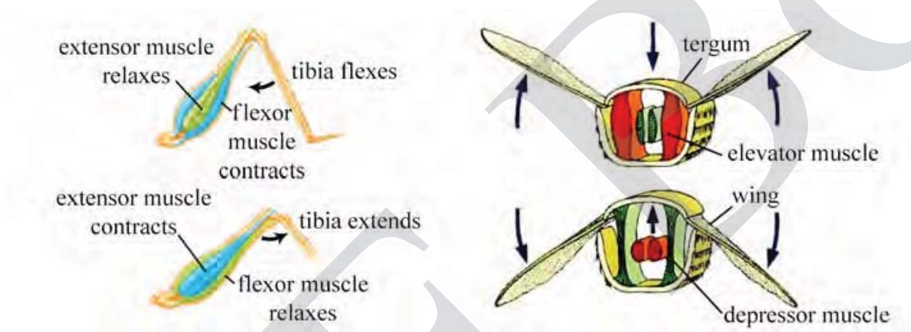
oco otion in grasshopper

u ping

The **flexor** and e tensor (antagonistic) muscles are attached to the internal surface of the exoskeleton. Flexor muscles bend a joint. xtensor muscles straighten it. The rear legs of a grasshopper are long and muscular and are adapted for hopping or u ping. When the flexor muscle contracts, the lower leg (tibia) is pulled towards the body. The hind leg is folded in a shape and ready for a jump. hen the extensor muscle contracts, the leg jerks backwards, propelling the grasshopper forward and up (Figure 3.2 a).

light

The movement (raising and lowering) of the wings, in flight of the grasshopper, is achieved by the alternate contraction of e tensor muscles (elevators) and le or muscles (depressors) located inside the exoskeleton of the thorax (Figure 3.2 b).



(a) umping (b) Flying

Figure 3.27 Muscles in jumping and flight of grasshopper

o e ent and oco otion in arious Co ple ni als and u ans

Antagonist and agonist skeletal muscles often occur in pairs, called antagonistic pairs. As one muscle contracts, the other relaxes causing movement or locomotion at different types of bony joints.

oco otion in ish

Fish have a strea lined od shape for s i ing in water to reduce friction. Fish moves forward as a result of the contraction and relaxation of (antagonistic) muscles called oto es on either side of the body and the tail or caudal fin propels the fish. The function of **fins** in fish is to alance the od in an upright position in water. Pectoral fins are used to steer the fish. Pel ic fins are used to balance the fish and prevent the body from diving or rolling (Figure 3.2).

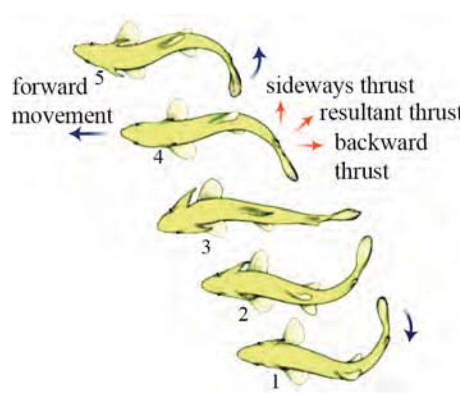
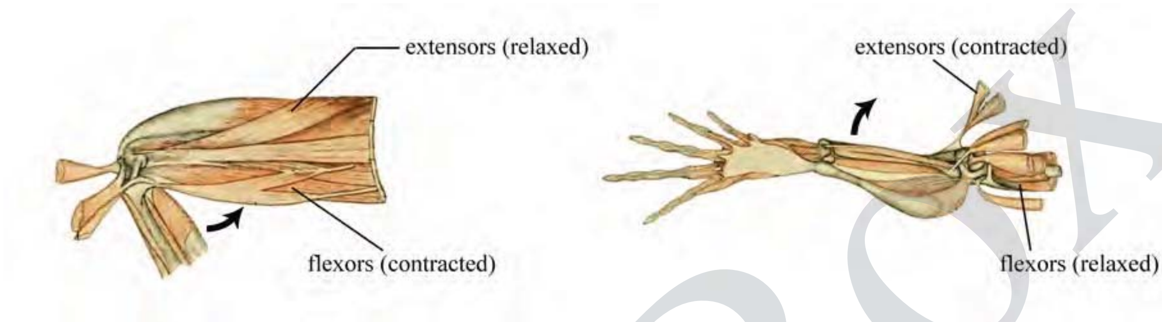


Figure 3.2 Swimming in fish

oco otion in rog

The frog s powerful hind legs are adapted for both s i ing and leaping. The strong e tensor muscles of the thigh contract, extending the limb and thrusting the foot against the ground or against the water. The thrust is transmitted through the body of the frog by the pel ic girdle and the spine so that the whole animal is pushed forward. le or muscles of the thigh contract to pull or flex the leg for the next extension (Figure 3.29).



(a) Flexion (b) xtension

Figure 3.29 Rear legs propel a frog in swimming and leaping

oco otion in ird

ost birds have approximately 1 different muscles, mainly controlling the wings, skin and legs. During flight, a bird moves its wings in weak upstrokes and strong do nstrokes to get lifted and fly in the air.

The antagonistic muscle pair of pectoral and supracoracoideus forms the major flight muscles. Both muscles are attached to the breast bone (sternum) but the pectoral muscles contract to cause downstroke of the humerus bone of the wings while the supracoracoideus causes the upstroke of the wings, providing li t.

n addition, circular movement of the wings, forward and then backward, during each downstroke, provides thrust that moves the bird forward through the air (Figure 3.30).

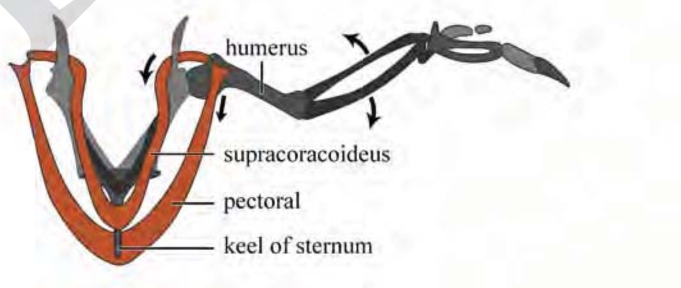


Figure 3.30 Muscles of wing flapping in flight of bird

oco otion in hu ans

There are about 0 skeletal muscles in the human body. ost of these muscles function in antagonistic pairs for locomotion and movement in humans.

The antagonistic muscle pairs carry out many types of movements. Some of which are as follows

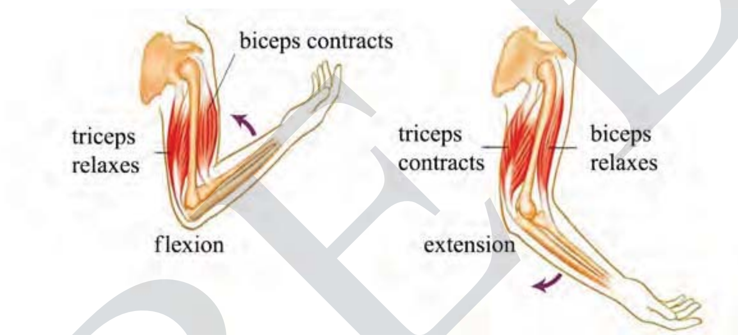
le ion and e tension

ne prominent example pair of muscles is iceps rachii and triceps rachii in the upper arm. Contraction of biceps brachii le es or pulls the forearm towards the upper arm. hen the triceps brachii is relaxed, le ion happens at the hinge joint at the elbow.

But when the biceps relaxes and the triceps contracts, the forearm is pulled away from upper arm. The locomotion is termed e tension (Figure 3.31 a).

Another example pair of muscles is the ha string and uadriceps muscles in the thigh of the legs. Contraction of the hamstring and relaxing of the uadriceps le the leg at the knee. Next, the leg is e tended at the knee by contraction of the uadriceps and relaxing of the hamstring muscles (Figure 3.31 b).

The working muscle is termed agonist and the resting muscle is the antagonist



(a)

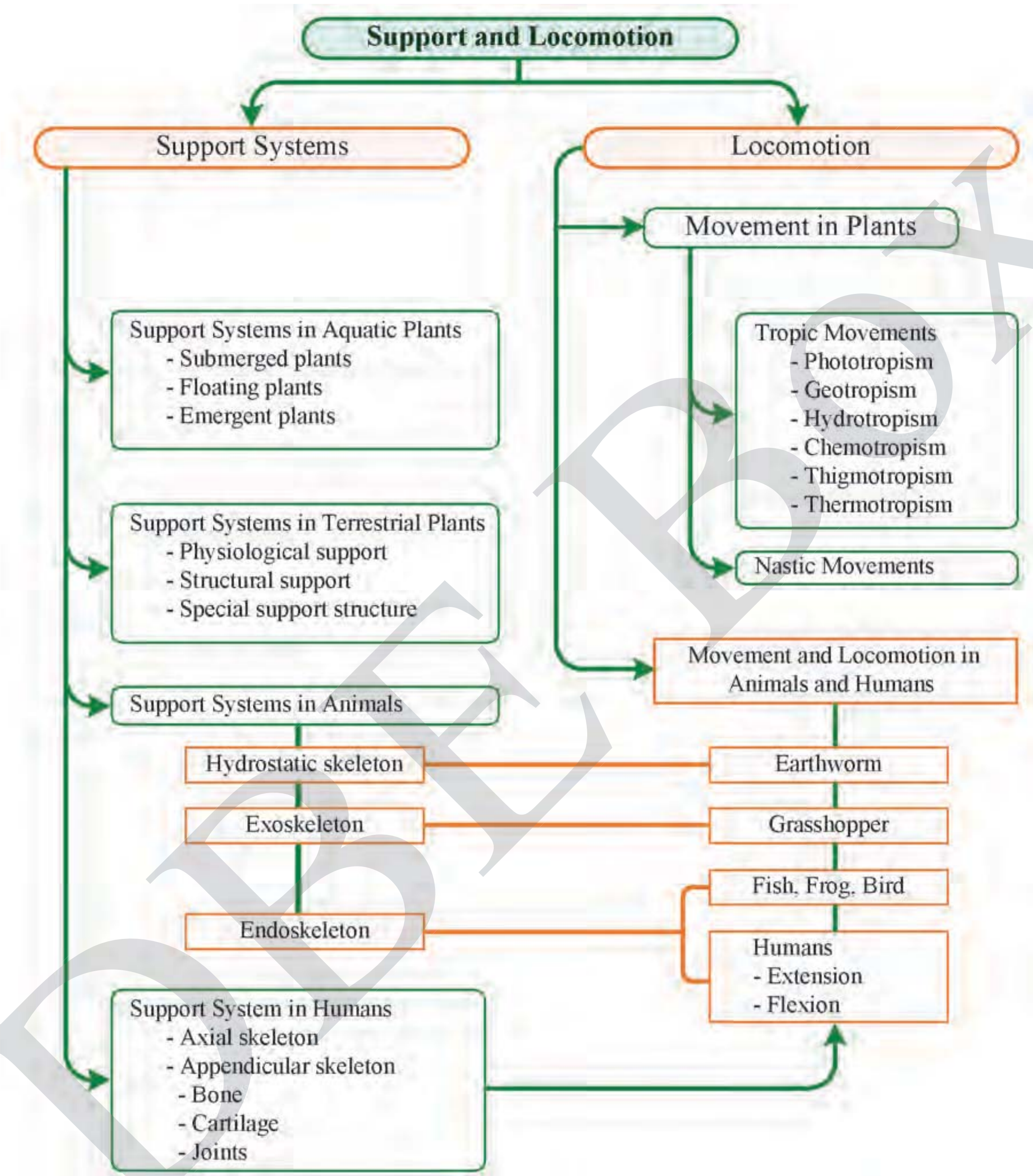
(b)

Figure 3.31 The arrangement and functions of skeletal muscles in an antagonistic pair (a) in the arm (b) in the leg of humans

e ie uestions

1. Distinguish the types of a uatic plants and describe the characteristics of one which grows below the surface of the water.
2. Why can floating plants exist above the surface of the water?
3. Describe the physiological support in plants.
4. State the structural support of plants and its effect.
. Clarify the types of special support structures found in terrestrial plants and state their functions.
6. How does the exoskeleton differ from the endoskeleton?
7. “Skeletal systems can vary in different animals”. Substantiate this statement.
. How do human endoskeletal system support the body
9. Different movements occur at joints between bones. Explain them with examples.
10. hy is it important to maintain a healthy musculoskeletal system
11. Differentiate between tropic and nastic movements in plants.
12. Define the term tropism and mention its types.
13. Mention the differences between phototropism and geotropism in plants.
14. How do *Mimosa* and *Nepenthes* response to touch
1 . hat is the significance of tropic movements in plants xplain any two types of tropic movements with fully labeled diagrams.
1 . How are movement and support maintained in an animal lacking an exoskeleton or endoskeleton
17. Explain how insects are able to jump and fly.
1 . Discuss how fish achieve locomotion and stability in swimming.
19. How are amphibians able to move both in water and on land
20. Describe the mechanisms of flight in birds.
21. Briefly explain the movement and locomotion of arms and legs in humans.

Concept ap


Support and Locomotion
Support Systems
Locomotion
Movement in Plants
Support Systems in Aquatic Plants
- Submerged plants
- Floating plants
- Emergent plants
Tropic Movements
- Phototropism
- Geotropism
- Hydrotropism
- Chemotropism
- Thigmotropism
- Thermotropism
Nastic Movements
Support Systems in Terrestrial Plants
- Physiological support
- Structural support
- Special support structure
Movement and Locomotion in Animals and Humans
Support Systems in Animals
Hydrostatic skeleton
Earthworm
Exoskeleton
Grasshopper
Fish, Frog, Bird
Endoskeleton
Humans
- Extension
- Flexion
Support System in Humans
- Axial skeleton
- Appendicular skeleton
- Bone
- Cartilage
- Joints

CHAPTER 4
A BODY SYSTEM TO SUSTAIN LIFE

Learning Outcomes

It is expected that students will

- state that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates
- determine the types of nutrients, including macronutrients and micronutrients which are important for living things and why they are important
- explain the importance of a healthy diet and maintaining a healthy digestive system
- identify and describe the structure and mechanisms involved in the digestive system of humans including the formations of the teeth
- understand the diseases that cause malfunction of the digestive system

4.1 NUTRITION

Nutrition is the process of taking food by an organism and utilization of food for energy. This is a vital process which helps living things to obtain their energy from various sources. Nutrients are the substances which provide nutrition and consists of carbohydrates, proteins, fats, vitamins and minerals. These essential components of food are called nutrients. Mode of nutrition varies from one species to another for their important life processes. There are two types of nutrition, autotrophic and heterotrophic nutritions.

(1) **Autotrophic nutrition** (able to make its own food)

In autotrophic nutrition, the organisms make or synthesize their own food from the simple inorganic materials. Plants are autophytes and they have an autotrophic mode of nutrition. There are two types of autotrophic nutritions.

(a) **Photosynthetic** plants use energy from the sun to make their own food.
e.g., all green plants

(b) **Chemosynthetic** organism consumes simple nonliving chemical nutrients such as hydrogen sulphide (H_2S), sulphur (S) and iron (Fe) to make their own food.
e.g., autotrophic bacteria

(2) **Heterotrophic nutrition** (unable to make its own food)

Heterotrophic nutrition is that mode of nutrition in which an organism cannot make or synthesize its own food from simple inorganic materials. Animals depend on other organisms for their food. Hence they have a heterotrophic mode of nutrition.
There are three main types of heterotrophic nutrition.

(a) **Holozoic nutrition** - the organisms feed by ingesting solid organic matter which is then digested and absorbed into their bodies.
e.g., humans, animals and insectivorous plants

(b) **Saprophytic nutrition** - feeding on dead and decaying matter. Include bacteria and fungi which digest the food externally before the nutrients are absorbed.
e.g., many bacteria and fungi

(c) Parasitic nutrition - the parasite obtains nutrients by living on or in the body of the host. e.g., dodder, fleas, lice and tapeworms

4.1.1 Plant Nutrition

Green plants synthesize their own food by the process of photosynthesis. In the process, they make their own food from CO_2 and H_2O by using sunlight in the presence of chlorophyll. The process of photosynthesis can be represented as:

1. The process of photosynthesis takes place in the green leaves of a plant.
2. The food is prepared by the green leaves of a plant in the form of a simple sugar called glucose.
3. The extra glucose is changed into starch that temporarily stored in the leaves of the plant.
4. Green plants convert energy of sunlight into chemical energy by making carbohydrate.

Photosynthesis

Photosynthesis is a metabolic reaction occurring in plants in which light energy converts raw materials into carbohydrates such as glucose which can be stored in cells and used as an energy source via respiration. Photosynthesis occurs in the chloroplasts of plant cells. Chloroplasts contain chlorophyll that transfers light energy into chemical energy. The whole process of photosynthesis can be shown by following equation:

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{12H_2O} \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} + \underset{\text{Water}}{6H_2O}$$

The photosynthesis takes place in the following four steps:

1. Absorption of sunlight energy by chlorophyll.
2. Conversion of light energy into chemical energy.
3. Splitting of water into hydrogen and oxygen by light energy.
4. Reduction of carbon dioxide by hydrogen to form glucose by the use of chemical energy.

Chlorophyll

Chlorophyll is a pigment that absorbs light of particular wavelengths (mainly blue and red). Chlorophyll in green plants is spread on stacks of membrane in the chloroplast.

Chloroplast

The site of photosynthesis in a cell of the leaf is chloroplast which contains chlorophyll. Chloroplasts are present in the photosynthetic cells (mesophyll cells) of green leaves of plants. These cells contain more chlorophyll than other plant cells.

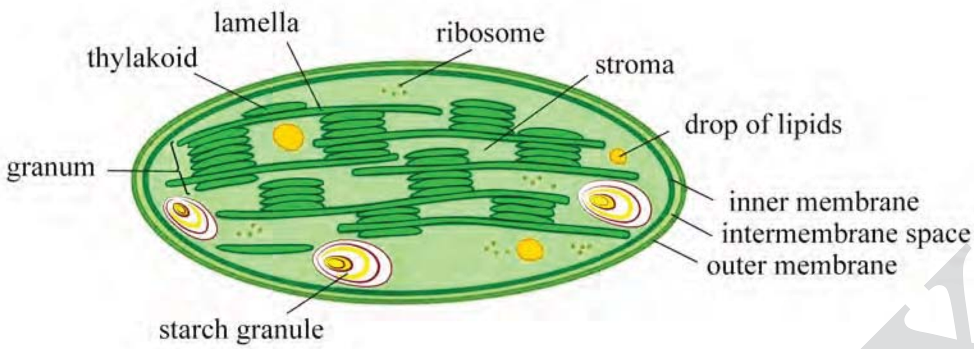


Figure 4.1 Structure of chloroplast

Experiment to demonstrate that starch is formed during photosynthesis

The experiments on photosynthesis depend on the fact that green leaves make starch as food and starch gives a blue-black colour with iodine solution.

A leaf can be tested for starch in the following steps:

1. The variegated leaf is boiled in water for a minute. This kills the protoplasm by destroying the enzymes and hence prevents further chemical changes. It also makes the cells more permeable to iodine solution.
2. Then, the leaf is boiled in methylated spirit to remove the chlorophyll. This turns into a white leaf and makes colour changes easier to see.
3. The leaf becomes brittle because of boiling in spirit. However, it can be softened by dipping into boiling water. It is then spread out in a petri-dish or on a glazed tile.
4. Iodine solution is placed on the leaf. If starch is present, the leaf turns blue-black. If there is no starch, the leaf is stained brown by iodine.

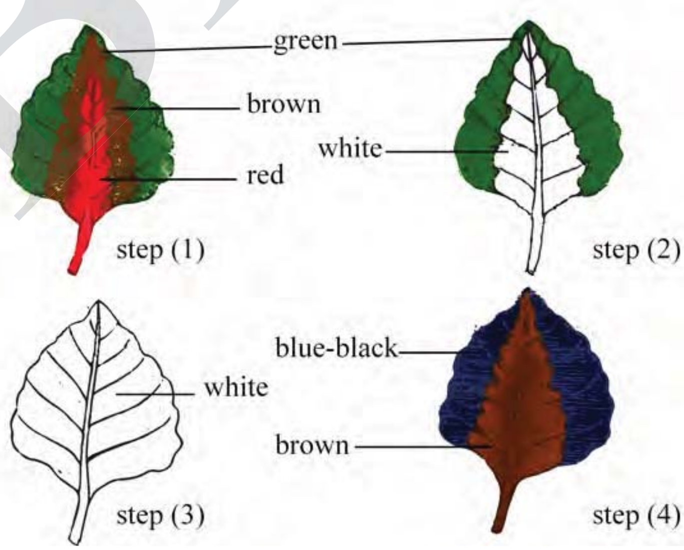


Figure 4.2 Starch test with variegated leaf

Factors affecting photosynthesis

ntensity of light concentration of carbon dio ide in the air te perature and ater are the important external factors that influence photosynthesis. Internal factors include chlorophyll content and the accumulation of the products of photosynthesis.

Intake of substances required for photosynthesis

Plants get the materials required for photosynthesis from their environment.

Table 4.1 Intake of substances required for photosynthesis

aterial	Method of intake by green plant	e t stage
ight	- ight is absorbed by chlorophyll in chloroplasts of plant cells mainly in the leaves.	- ight energy is changed into chemical energy.
ater	- ater is absorbed by the roots and travels up the yle fro the root to the stem and then into the leaves.	- ater is split to provide hydrogen atoms. Oxygen is released.
arbon dio ide	- Carbon dioxide diffuses from the at osphere into the leaves through the stomata.	- arbon dio ide co bines ith the hydrogen from water. Through a series of reactions glucose is for ed and is stored te porarily in the leaf as starch.

4.1.2 Types of Nutrients

Types of Nutrient in Plants

Plants require a number of inorganic nutrients. Plants require essential elements such as C, H and O which are derived from the atmosphere and the other elements are supplied from the soil or by fertilizer.
The plant nutrients can be divided into t o groups:

1. **Macronutrients**: carbon (C), oxygen (O), hydrogen (H), nitrogen (N), phosphorus (P) potassiu ( ) calciu (a) agnesiu (g) and sulphur ( )
2. **Micronutrients**: boron ( ) iron (e) chlorine (l) anganese (n) inc (n) copper (Cu), molybdenum (Mo) and nickel (Ni)

The plants need large a ounts of the acronutrients and trace a ounts of the micronutrients. The functions of the macronutrients in plant are described in the following table.

Table 4.2 Macronutrients for plants

utrients	unctions	Effects of deficiency
arbon ( )	- Part of carbohydrates proteins and fats have a role to play in the general etabolis s of plant	- Affects the normal growth and develop ent of plants
Hydrogen (H)		
Oxygen (O)		

Table 4.2 Macronutrients for plants (continued)

Nutrients	Functions	Effects of deficiency
Nitrogen (N)	- Components of nucleic acids, amino acids and proteins - Affects shoot-root growth, density, colour, disease resistance and stress tolerance	- Chlorosis or yellowing of leaves, stunting of plants, dormancy of lateral buds and late flowering
Phosphorus (P)	- Components of nucleic acids and adenosine triphosphate - Affects rate of seedling development, maturation and root growth	- Purple or red spots on leaves, dark green leaves, premature falling of leaves
Potassium (K)	- Activates enzymes and starch synthesis. Important in maintaining turgor pressure in plants - Affects drought tolerance and disease resistance	- Chlorosis, scorched leaf tips, shorter internodes, loss of apical dominance, stunted growth and premature death of plants
Calcium (Ca)	- Formation of cell wall, maintenance of membrane structure, permeability and importance in cell division	- Stunted growth, necrosis of young meristematic regions
Magnesium (Mg)	- Important component of chlorophyll and activates many enzymes	- Chlorosis of older leaves with necrotic or purple spots and premature leaf abscission
Sulphur (S)	- Present in certain amino acids, proteins, membrane and coenzymes	- Chlorosis of younger leaves, stunted growth, accumulation of anthocyanin, terminal buds develop prematurely

Types of nutrients in animals

Nutrients are the substances that are required for the nourishment of animals. Nutrients are of two types:

1. **Macronutrients** are needed in relatively large amounts. The macronutrients are carbohydrates, fats, proteins, fibres and water. Macronutrients that provide energy include carbohydrates, fats and proteins derived from plants and animals. Macronutrients that do not provide energy include fibres and water. Water is essential for metabolism.
2. **Micronutrients** are needed in small quantities. The micronutrients are represented by vitamins and minerals. **Vitamins** are needed for a large number of cellular and extracellular chemical reactions. Vitamins are essential for energy production,

immune system function, blood clotting and other body functions. Some important vitamins are vitamin A, vitamin B complex, vitamin C, vitamin D and vitamin E. **Minerals** are used in chemical reactions as well as in structural components of cells and tissues. Minerals play an important role in growth, bone and muscle health and other processes. Some important minerals are calcium, iodine, iron, magnesium and potassium.

Table 4.3 Macronutrients for humans

Types of nutrient	Food sources	Functions	Effects of deficiency
Carbohydrates	- Rice, bread, beans, milk, popcorn, potatoes, cookies, spaghetti and soft drinks	- Give the body energy - The best source of fuel for the body	- Nausea, dizziness, constipation, lethargy, bad breath, loss of appetite, excessive breakdown of proteins
Proteins	- Meat, fish, eggs, poultry, dairy products, legumes, nuts and seeds	- Provide energy - Help to build, maintain and repair body tissues - Involve in the interaction of several organs - Help to regulate cell growth	- Confusion, slow wound healing, food cravings, fatigue, muscle weakness, thin hair, weak nails, weight loss, swelling of the gut
Fats	- Butter, animal fats, eggs, milk, chocolate, avocados, fish oil and vegetable oil	- Provide energy - Cushion organs - Carry vitamins - Act as an insulator and provide taste	- Dry, scaly, dull skin - Dry, brittle hairs - Hunger
Fibres	- Cereals, whole grain bread - Fruits such as apples, berries, pears, melons, oranges, bananas - Vegetables such as peas, beans, potatoes with skin - Nuts and seeds	- Lower cholesterol and stabilize blood glucose level - Help to prevent constipation - Help the stomach feel fuller	- Leads to risk of heart disease, constipation, diabetes, bowel cancer

Table 4.3 Macronutrients for humans (continued)

Types of nutrient	Food sources	Functions	Effects of deficiency
Water	- Drinking water, hot and cold drinks, succulent fruits and vegetables	- Lubricates the joints, boosts skin health and beauty - Cushions the brain, spinal cord and other sensitive tissue - Regulates body temperature - Flushes body waste - Helps to maintain blood pressure	- Dry skin, dry or sticky mouth and tongue, constipation, thirst and hunger, tiredness, headache, dark urine and kidney failure

4.1.3 A Healthy Diet

Characteristics of a healthy diet

(1) **Balanced diets** contain carbohydrates, lipids, proteins, minerals and vitamins along with dietary fibres and water. These substances must be in the right amount and in the correct proportions to keep healthy.

(2) **Balanced calories** with physical activity or energy output.

(3) **To manage weight**, consume more fruits, vegetables, whole grains, fat-free or low-fat dairy products, seafood which can reduce risks of constipation and heart disease.

(4) **Consume lower** sodium, saturated fats, trans fats, cholesterol, added sugars, refined grains to prevent diabetes and cardiovascular diseases.

(5) **Nutritious diet** includes a selection of healthy food groups: i.e. grains, vegetables, fruits, dairy products and proteins. Consider variety, balance, proportionality and moderation.

(6) **Healthy eating** means eating a variety of foods that give the nutrients needed to maintain health, feel good and have energy. Essential nutrients are carbohydrates, proteins, fats, vitamins, minerals, omega-3 fatty acids, fibres and water.

(7) **Portion size** is a **recommended serving size** which is the amount of each food that a person should eat during a meal or snack.

(8) **Healthiest diet** in the world is perhaps the Mediterranean Diet which includes abundance of fruits, vegetables, whole grains, legumes, nuts, olive oil, fish and poultry as lean sources of proteins.

(9) Drinking enough **water** is important for health. Water is important for food digestion, waste elimination and all other body functions and metabolic activities.

4.2 DIGESTIVE SYSTEMS

Single-celled organisms (as well as sponges) digest their food **intracellularly**. They lack a digestive tract. Other animals digest their food **extracellularly** within a digestive cavity. In this case, the digestive enzymes are continuously released into the digestive cavity. In coelenterates (such as *Hydra*), the digestive cavity called a **gastrovascular cavity** has only one opening that serves as both mouth and anus (Figure 4.3).

Specialization occurs when the **digestive tract** or **alimentary canal** has a separate mouth and anus, so that transport of food is **one-way**. The most primitive digestive tract is seen in nematodes (roundworms) where it is simply a tubular gut lined by an epithelial membrane. Earthworms have a digestive tract specialized in different regions for the ingestion, storage, digestion and absorption of food. All higher animal groups including all vertebrates show similar specializations (Figure 4.4).

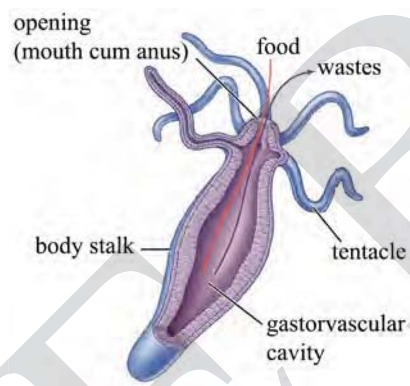


Figure 4.3 Gastrovascular cavity of *Hydra*, a coelenterate

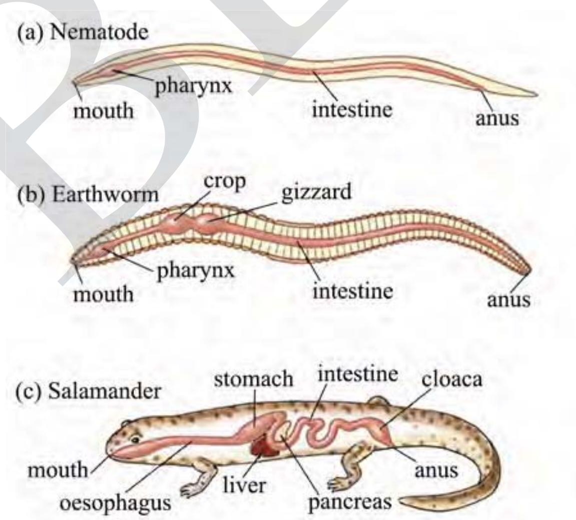


Figure 4.4 One-way digestive tract of (a) nematode (b) earthworm and (c) salamander

4.2.1 Structure of the Human Digestive System

Regions of the alimentary canal and their functions

The **alimentary canal (digestive tract)**, starting with a mouth and ending with an anus, is a tube running through the body. Food digested in the alimentary canal are absorbed and the indigestible residues are expelled (egested) (Table 4.4 and Figure 4.5).

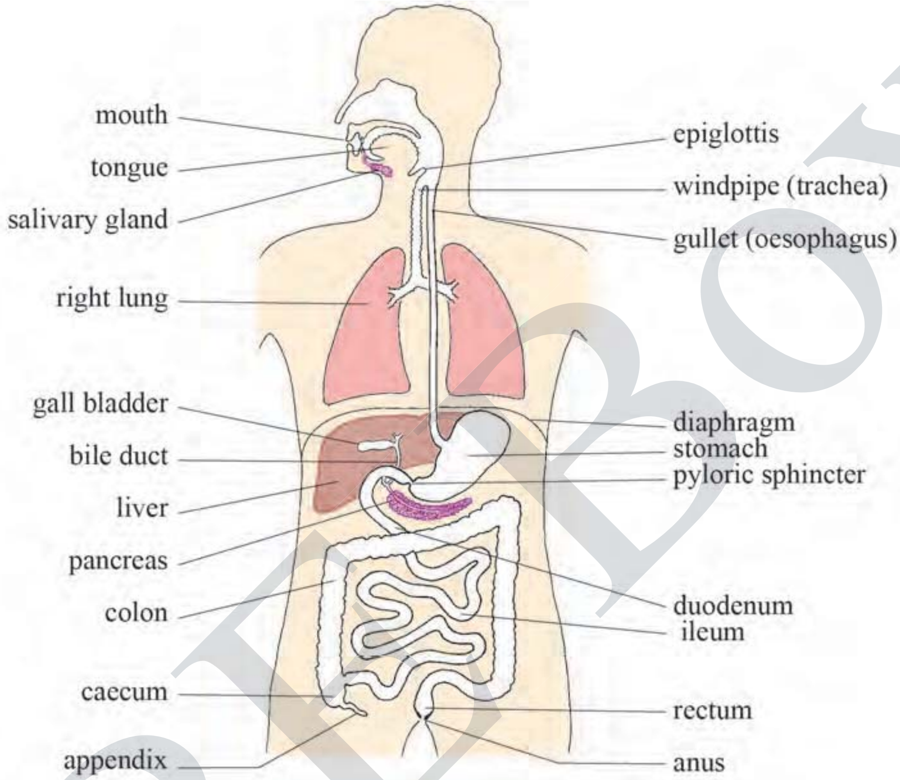


Figure 4.5 Generalized diagram of the alimentary canal in human

Two muscle layers, longitudinal and circular, cover the alimentary canal. The inside of the alimentary canal is lined with layers of cells forming an **epithelium** (Figure 4.6). There are also cells in the lining that produce **mucus**. Mucus is a slimy liquid that lubricates the lining of the canal and protects it from wear and tear and from attack by the **digestive enzymes**. Some of the digestive enzymes are produced by cells in the lining of the alimentary canal. Among the **accessory organs (**salivary glands, pancreas, liver and gall bladder) the **salivary glands** and **pancreas** produce other digestive enzymes. The **liver** produces **bile** (not enzyme) into the gall bladder and duodenum. The alimentary canal has many blood vessels in villi of its walls, close to the lining. They absorb the digested food from the alimentary canal.

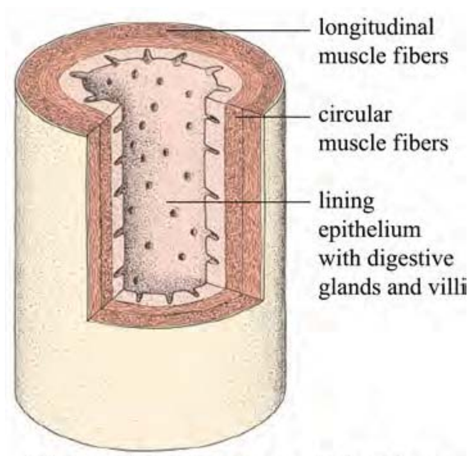


Figure 4.6 The general structure of the alimentary canal

Table . unctions of ain parts of the hu an digestive syste

Parts	unctions
outh	- n estion of food echanical i estion by teeth che ical i estion of starch by a ylase for ation of a bolus food for s allo ing aided by the tongue
esophagus (gullet)	- Transfers food fro the outh to the sto ach by peristalsis
to ach	- Produces hydrochloric acid hich ills bacteria and provides opti u pH for the en y es pepsin to be activated also produces gastric uice hich contains pepsinogen (inactivated) hen pepsinogen encounters ith hydrochloric acid it beco es active pepsin pepsin digest proteins into peptides (che ical digestion) physical digestion ta es place by churning to i food thoroughly ith en y es for ing chy e.
uodenu	- irst part of the s all intestine receives pancreatic uice fro pancreas for che ical i estion of starch proteins and fats receives bile to e ulsify fats into tiny fat droplets (a for of physical i estion) neutrali es acid chy e fro the sto ach to have opti u pH for the en y es secretes altase hich converts altose into glucose secretes peptidase hich converts peptides into a ino acids
leu	- econd part of the s all intestine en y es in the epithelial lining carry out che ical i estion of altose and peptides very long and has villi to increase surface area for a sorption of digested food olecules
olon	- irst part of the large intestine a sorption of ater fro undigested food absorption of bile salts to pass bac to the liver
ectu	- econd part of the large intestine stores faeces
Anus	estion of faeces
Associated glands	**unctions**
alivary glands	- aliva contains a ylase hich digests starch into altose saliva lubricates food and a es s all pieces stic together
iver	- a es bile containing salts to e ulsify fats into tiny fat droplets assi ilation of digested food such as glucose converts into glycogen ea ination of e cess a ino acids
all bladder	- tores bile (hich is ade in liver) secretes bile into the duodenu via the bile duct

Table . unctions of ain parts of the hu an digestive syste (continued)

Associated glands	unctions
Pancreas	- ecretes pancreatic uice into the duodenu via pancreatic duct pancreatic uice contains en y es a ylase trypsinogen and lipase a ylase converts starch into altose trypsinogen is inactive after having opti u pH it beco es an active for of trypsin hich converts proteins into peptide lipase converts tiny fat droplets into glycerol and fatty acids

4. . he Process o i estion

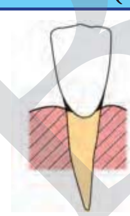
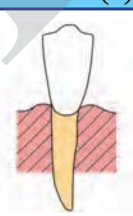
igestion is the process by hich the large co ple olecules in food are bro en do n into s aller olecules that can be used by the body. t consists of echanical digestion and che ical digestion.

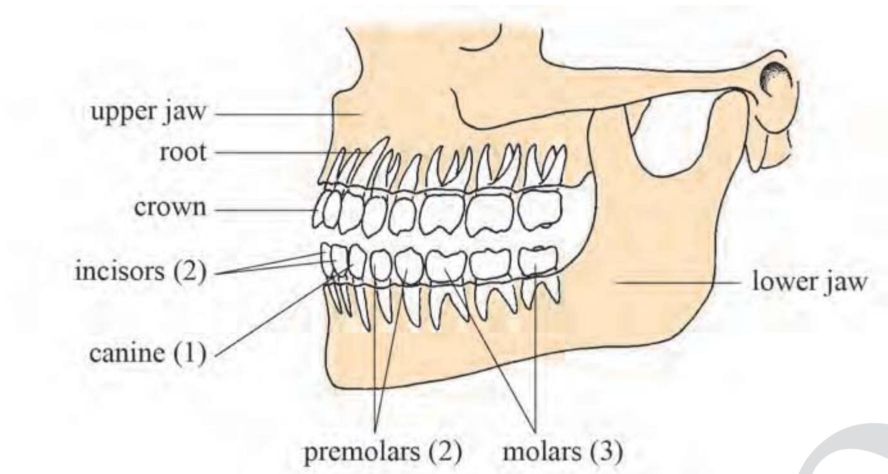
echanical i estion includes: che ing in the outh and churning in the sto ach. Che ical i estion involves en y es. These are proteins that function as iolo ical catalysts.

echanical i estion

The process of echanical digestion ainly occurs in the outh by eans of the teeth through a process called astication or grinding of food into s aller pieces. Hu ans are o nivores (organis s that eat ani al and plant aterials). Thus although hu ans have different teeth termed incisors, canines, premolars and molars (Table 4.5 and Figure 4.7), they do not sho such big variations in si e and shape as e.g. teeth of a olf a carnivore.

Table 4.5 Summary of types of human teeth and their functions

Types	ncisor (i)	anine (c)	Pre olar (p)	olar ( )
iagra s				
Positions in outh	front	either side of incisors	behind canines	bac behind pre olars
escriptions	chisel-shaped (sharp edge)	ore pointed than incisors	have t o points (cusps) have one or t o roots	have four or five cusps have t o or three roots
unctions	biting off pieces of food	si ilar function to incisors	tearing and grinding food into s all pieces	che ing and grinding food into s aller pieces



igure . Hu an a s and teeth (left side vie)

ental or ula in hu ans

The dental for ula e presses the arrange ent of teeth in each half of the upper a and the lo er a . The entire for ula is ultiplied by t o to e press the total nu ber of teeth.

The dental for ula for per anent teeth in hu ans is: $i\frac{2}{2}c\frac{1}{1}pm\frac{2}{2}m\frac{3}{3}=32$

ach half of the upper a and the lo er a has 2 incisors (i) 1 canine (c) 2 pre olars (p) and olars ( ) respectively. An adult hu an has a total of 2 per anent teeth.

Co parison o the teeth o a als ase on i erent iets

Table . o parison of the teeth of a als based on different diets

iets	nivores	arnivores	Herbivores
a ples	an	og	abbit
ental for ulae	$i\frac{2}{2}c\frac{1}{1}p\ \frac{2}{2}\ \frac{}{}\ 2$	$i-c\frac{1}{1}p\ -\ \frac{2}{}\ 2$	$i\frac{2}{1}c-p\ \frac{}{2}\ -\ 2$
ood sources	Plants and ani als	Ani als	Plants

Che ical i estion

igestion is ainly a che ical process and consists of brea ing do n large olecules of food into s all olecules. The s all olecules can be absorbed by the blood vessels of the epitheliu of the ali entary canal.

o e food such as lucose in fruit uice for e a ple could pass through the alls of the ali entary canal and enter the blood vessels ithout digestion. ost food ho ever is solid and cannot get into blood vessels. igestion is the process by hich solid food is dissolved to a e a solution hich is soluble.

The che icals that dissolve or digest the food are digestive en y es. All the solid starch in carbohydrate foods such as bread and potatoes are digested into lucose hich is soluble in ater. The solid proteins in eat eggs and beans are digested to soluble substances called a ino aci s. ats are digested into t o soluble products called lycerol and atty aci s.

se o i este oo

The products of digestion such as glucose fats and a ino acids are carried around the body in the blood. The upta e and use of food is called assi ilation. uring respiration glucose is o idi ed to for carbon dio ide ater and energy to drive cellular etabolis . ats are built into cell e brane and other cell structures. A ino acids in the cells are built up ith the aid of en y es into proteins hich ill beco e en y es hor ones and other cellular structures.

4.

4. .1 enti yin a ealthy i esti e yste

(1) The organs of the gut should al ost al ays be oving driven by uscles in its thin alls. These uscles consist of an outer longitudinal layer and an inner circular layer. The coordinated contractions of these muscle layers push food and fluids along the gut in a process called peristalsis.

(2) igestive en y es fro glands in the ucosa or lining of the outh sto ach and s all intestine help in the digestion of food.

( ) uices secreted by the salivary glands liver and pancreas help a e food dissolve in ater so that nutrients can be passed easily into the blood strea .

( ) Teeth should be healthy to cut and grind solid food into digestible s aller pieces before s allo ing the food into sto ach through the gullet or oesophagus.

( ) The s allo ed food ust be directed to enter the oesophagus and be prevented fro entering the indpipe or trachea to the lungs. A cartilage flap called epiglottis ust be functioning to close the indpipe during s allo ing.

( ) The colon ust ove nor ally to e pel the faeces (egestion) easily and regularly.

( ) The digestive tract and accessory organs such as liver pancreas and gall bladder should be free of infection ulcers and abnor al gro th.

( ) The pH of gastric uice should be acidic in the sto ach but al aline in the s all intestine.

4. . al unctionin i esti e yste

The digestive tract is ade up of the outh oesophagus sto ach s all and large intestines and rectu ith liver gall bladder and pancreas as accessory organs.

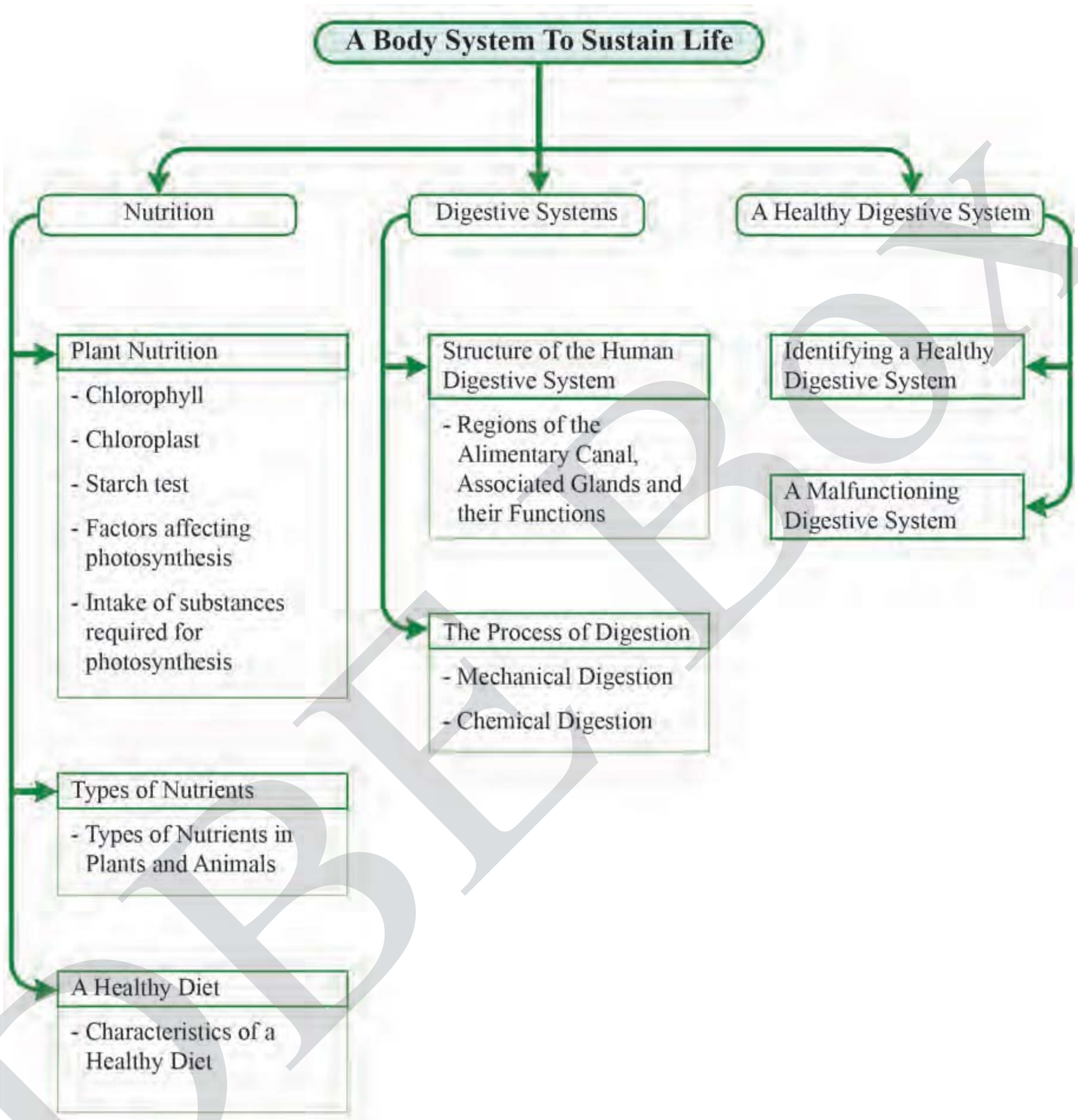
any sy pto s can signal proble s ith the digestive tract. These include abdo inal pain blood in the stool bloating constipation diarrhea heartburn incontinence nausea and vo iting and difficulty in s allo ing. The sy pto s indicate the occurrence of so e co on iseases in the digestive syste .

o e e a ples of co on diseases in hu an gut and teeth include: (1) constipation (2) appendicitis ( ) gall stones ( ) sto ach ulcers ( ) gastrointestinal infections ( ) hepatitis ( ) polyps and colon cancer and ( ) tooth decay (dental caries).

e ie uestions

1. ention the ra aterials of photosynthesis and its e uation.
2. Ho ould you de onstrate that starch is for ed during photosynthesis
3. Write briefly on the intake of substances required for photosynthesis.
. ive the functions of acronutrients in plants.
5. Tabulate the food sources of carbohydrates and proteins and the effects of their deficiency.
. hich acronutrients prevent constipation ention their functions food sources and effects of deficiency.
. escribe the nutrients that the ani als need to sustain life.
. hat icronutrients are essential for hu an
. hat are the acronutrients Ho i portant are they in a hu an diet
1 . hat ill happen to the hu an body if the diet is not balanced ocus on nutrient deficiencies.
11. escribe the structures and functions of teeth in hu an.
12. hy are foods needed to be digested
1 . here do che ical digestion and absorption of food occur in the hu an digestive tract
1 . nu erate the factors hich aintain a healthy digestive syste .
1 . plain so e of the co on sy pto s and diseases of alfunctioning digestive syste .

Concept ap


A Body System To Sustain Life
Nutrition
Digestive Systems
A Healthy Digestive System
Plant Nutrition
- Chlorophyll
- Chloroplast
- Starch test
- Factors affecting photosynthesis
- Intake of substances required for photosynthesis
Types of Nutrients
- Types of Nutrients in Plants and Animals
A Healthy Diet
- Characteristics of a Healthy Diet
Structure of the Human Digestive System
- Regions of the Alimentary Canal, Associated Glands and their Functions
The Process of Digestion
- Mechanical Digestion
- Chemical Digestion
Identifying a Healthy Digestive System
A Malfunctioning Digestive System

CHAPTER 5
CONTINUATION OF LIFE

Learning Outcomes

It is expected that students will

- explain the types of reproduction in plants and animals
- describe the formation and role of gametes
- explain how chromosomes behave during reproduction
- identify the steps in the processes of mitosis and meiosis and compare the two processes
- explain the role of chromosomes and genes in the inheritance of characteristics and on the continuation of life

5.1 REPRODUCTION

The production of new organisms from the existing organisms of the same species is called reproduction. Reproduction is essential for survival of species on earth. The process of reproduction ensures continuation of life on earth.

5.1.1 Reproduction in Fungi and Plants

Two main types of reproduction found in fungi and plants are asexual and sexual reproductions.

Asexual reproduction in cyanobacteria, fungi and plants

A new individual produced from a single parent without involving the sex cell (gamete) is called asexual reproduction. Asexual reproduction may occur through binary or multiple fission, budding, fragmentation, spore formation and vegetative propagation.

Fission

When the parent organism reaches its maximum growth, it splits to form two new organisms. e.g., Cyanobacteria, etc. (Figure 5.1)

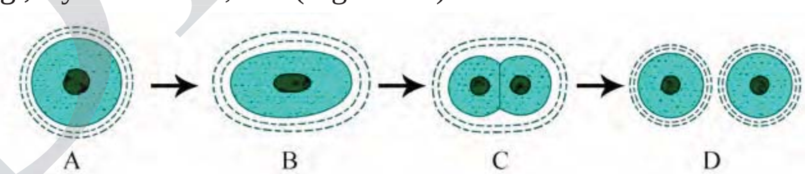


Figure 5.1 Asexual reproduction in Cyanobacteria by binary fission

Budding

In budding, a small part of a body of the parent organism grows out as a bud which then detaches and becomes a new organism. e.g., Yeast (Figure 5.2)

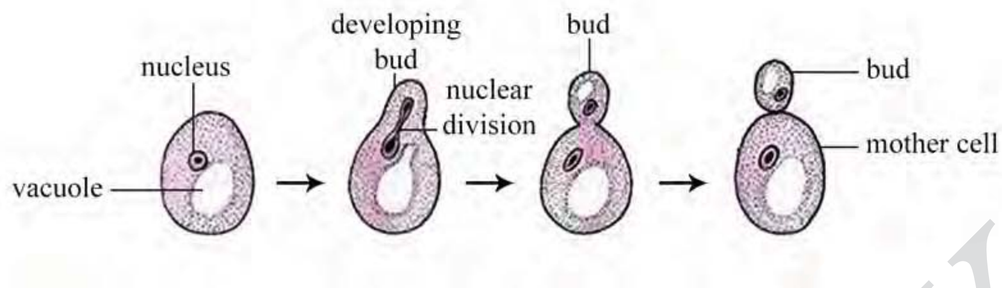


Figure 5.2 Asexual reproduction in yeast by budding

Fragmentation

The breaking up of the body of simple multicellular organism into two or more fragments, each fragment subsequently grows to form a new complete organism.
e.g., *Spirogyra* (a green filamentous alga) (Figure 5.3)

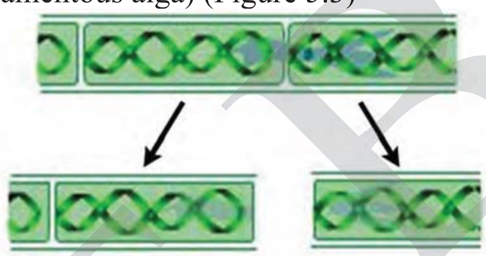


Figure 5.3 Asexual reproduction in *Spirogyra* by fragmentation

Spore formation

The parent plant produces many microscopic reproductive units called spores inside the spore sac. When the spore sac (sporangium) bursts, then the spores spread into air. When these spores stand on food or soil, under favorable condition they germinate and produce the new plants. e.g., Fern (Figure 5.4)

Figure 5.4 Asexual reproduction in Fern by spores

Vegetative propagation

In vegetative propagation, new plants are obtained from the parts of old plants such as stems, leaves or roots without the help of any reproductive organ. The green grass grows in the field after rain from the dry, old stem of the grass plant by the method of vegetative propagation.

Similarly, *Bryophyllum* plants can be reproduced by vegetative propagation by its leaves; gingers grow from the nodes of rhizomes, potato grows from the bud or eye of the tuber (Figure 5.5, 5.6 and 5.7).

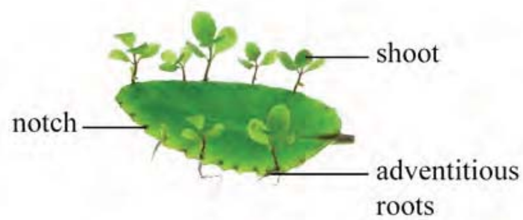


Figure 5.5 Vegetative propagation of *Bryophyllum* by leaves

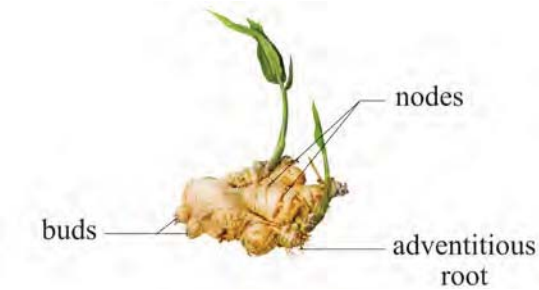


Figure 5.6 Vegetative propagation of ginger by rhizome

Figure 5.7 Vegetative propagation of potato by tuber

Artificial methods of vegetative propagation

The process of growing many plants from one plant by man-made method is called artificial method of vegetative propagation.

1. **Cutting**: A small part of root, stem, or leaves from a plant which is cut with a sharp knife is called cutting. A cut piece of the plant necessary to have some buds on it. e.g., rose, sugarcane, cactus (Figure 5.8).
2. **Layering**: It is a type of vegetative multiplication in which shoot of parent plant is allowed to develop roots while it is intact with the plant. After the development of enough roots, the shoot is detached from the parent plant to plant in the medium to lead an independent life. In layering, rooted branch is called a **layer**. e.g., rubber, croton (Figure 5.9).
3. **Grafting**: The cut stems of two different plants (one with roots and the other without roots) are joined together to grow as single plant is called grafting. The new plant has the characteristics of both plants. The cut stem having roots is called **stock** and the cut stem of another plant without roots is called **scion**. e.g., apple, mango, avocado (Figure 5.10).
4. **Budding**: Budding is a form of grafting most often used commercially. In this procedure, just the axillary buds are grafted onto the stem of another plant. e.g., rose, avocado, plum, citrus (Figure 5.11).

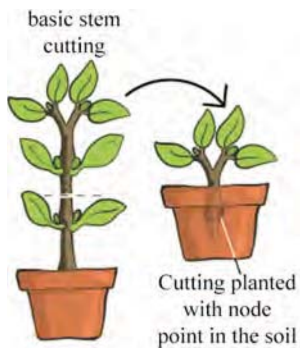


Figure 5.8
Vegetative propagation by cutting

Figure 5.9
Vegetative propagation by layering

Figure 5.10
Vegetative propagation by grafting

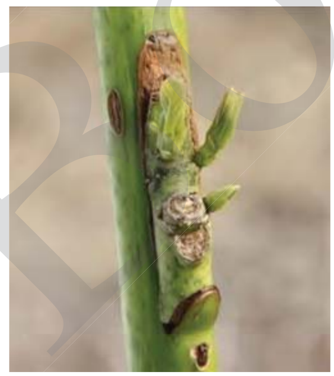


Figure 5.11
Vegetative propagation by budding

Micropropagation (Tissue Culture)

The new plants are produced from a small piece of the plant tissue (e.g., branch tip, root tip, leaf portion) in growing medium (agar medium).

Sexual reproduction in plants

The production of new plant from two parent plants by the use of sex cells (gametes) is called sexual reproduction. In plants, the sex organs are carried within the flowers.

Female gamete

Fertilization takes place inside the ovary inside which is the female gamete. One or many ovules are found attached to the inner wall of the ovary by means of funicles.

The body of the ovule is termed as the nucellus and one or two layers of integuments cover it. A pore, left uncovered, at the tip of the ovule, is the micropyle. Embedded in the nucellus is a large oval-shaped embryo sac, containing eight nuclei. Three of these are situated at the micropylar end. The biggest is called the egg cell or the female gamete. The other two are the synergids. At the opposite end are three nuclei, known as the antipodal cells. At the centre of the embryo sac are two polar nuclei (Figure 5.12).

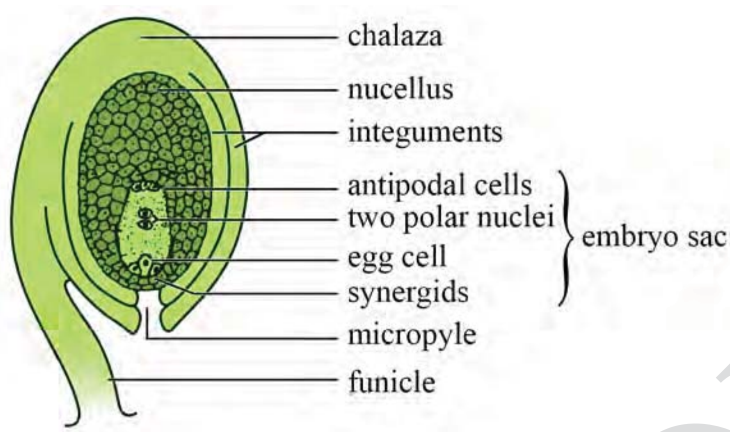


Figure 5.12 L.S. of ovule

Male gamete

The formation of male gamete takes place inside the pollen, a more or less rounded structure. It is uninucleate and possesses a two-layered wall. The inner wall or the intine is soft and thin. The outer wall or the exine is tough and often provided with spinous outgrowth. Some weak spots called germ pores may be present in the exine.

At the time of pollination, the stigma is viscous with a sticky substance containing sugar and other compounds. This substance stimulates the pollen grains to germinate.

Just before pollination, the nucleus of the pollen divides into two, the tube nucleus and the generative nucleus. On pollination, the pollen begins to germinate and the intine protrudes through the germ pore of the exine and elongates to form a pollen tube. The tube nucleus, carried along with the generative nucleus at the tip of the pollen tube controls the growth of the pollen tube.

The pollen tube penetrates the stigma and grows down the style until it finally reaches the ovule. By that time, the generative nucleus has already divided into two male gametes (Figure 5.13).

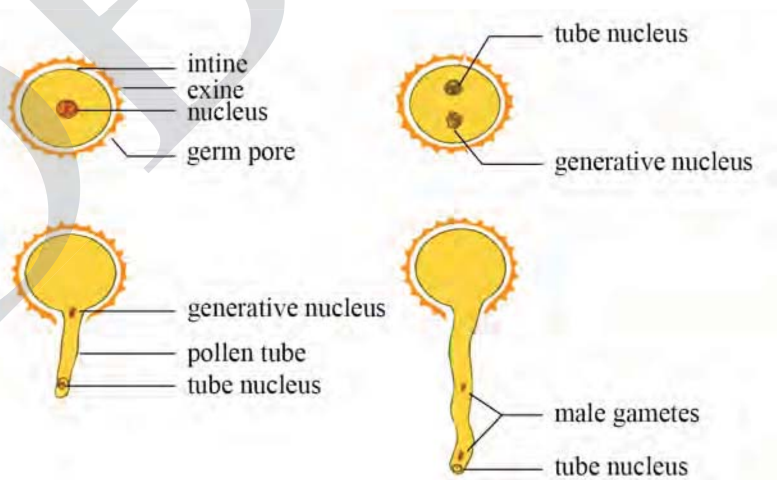


Figure 5.13 Germinating pollen grain

Fertilization

The pollen tube enters the ovule through the micropyle and it passes through the nucellus to approach the embryo sac. Then the tip of the pollen tube dissolves and the two male gametes are set free into the embryo sac. The tube nucleus disintegrates eventually.

One of the two male gametes fuses with the female gamete or egg cell, resulting in the fertilized egg or oospore. This process is termed as "fertilization". The two polar nuclei fuse to form the definitive or secondary nucleus. This in turn fuses with the second male gamete to form the primary endosperm nucleus.

The fusion of three nuclei, i.e. the two polar nuclei and the male gamete is therefore termed as "triple fusion". One male gamete fuses with the egg cell and the other with the two polar nuclei and that is why this process of fertilization and triple fusion are together known as "double fertilization".

During the process of fertilization, the synergids direct the male gamete towards the egg cell and the polar nuclei. They then disintegrate. The antipodal cells disappear before fertilization (Figure 5.14).

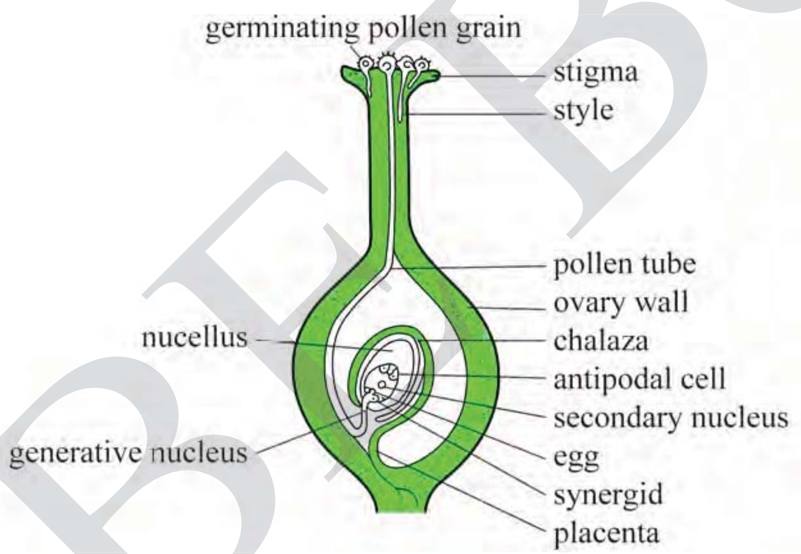


Figure 5.14 L.S. of the ovule showing the process of fertilization

Changes after fertilization

After fertilization, the stigma, style, stamens and petals wither and fall off. The sepals may fall off in some plants, in others they may persist until the formation of the fruits. The ovules develop into seeds and the ovary as a whole changes to form a fruit. The embryo sac enlarges and the fertilized egg grows and gives rise to an embryo. At the same time, the primary endosperm nucleus divides repeatedly to form the endosperm which stores food material for the growing embryo. The integuments become the seed coats.

5.1.2 Reproduction in Animals

Two types of reproduction, asexual and sexual, are found among the animals. Asexual means 'without sex' and this method of reproduction does not involve gametes (sex cells). In sexual reproduction, gametes from male and female combine to form an embryo which then grows into a young organism.

Asexual reproduction in animals

Some species of invertebrate animals are able to reproduce asexually by fission, fragmentation, budding or parthenogenesis. Some protists such as *Amoeba* reproduce by fission whereas sponges and some echinoderms reproduce by fragmentation. In some insects such as bees reproduce by parthenogenesis. *Hydra* is a small animal, 5-10 mm long, which lives in ponds attached to pondweed. *Hydra* has an asexual method of reproduction called **budding**. But *Hydra* can also reproduce sexually by gametes (Figure 5.15).

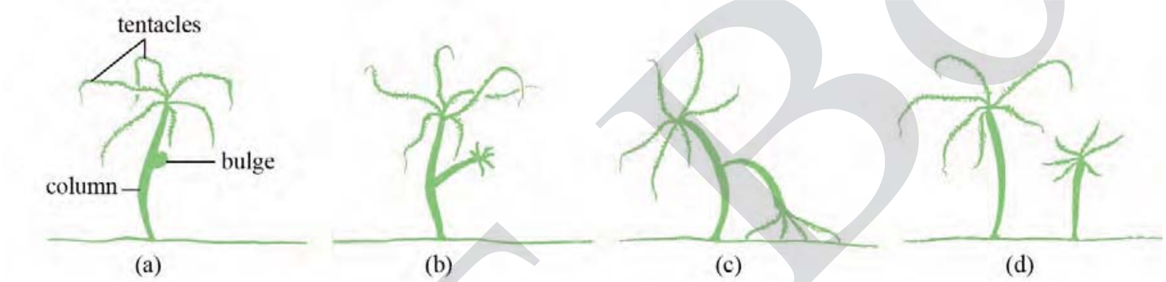


Figure 5.15 Asexual reproduction by budding in *Hydra* (a) a group of cells on the column starts dividing rapidly and produces a bulge (b) the bulge grows and develops tentacles (c) the daughter *Hydra* pulls itself off the parent and (d) the daughter becomes an independent animal

Sexual reproduction in animals

Sexual reproduction involves the production of sex cells. These sex cells are called **gametes** and they are made in reproductive organs called testes (in male) and ovaries (in female). The process of cell division that produces the gametes is called **meiosis**. In sexual reproduction, the male and female gametes come together and fuse (**fertilization**), i.e. their cytoplasm and nuclei join together to form a single cell called a **zygote**. The zygote or embryo then grows into a new individual (Figure 5.16).

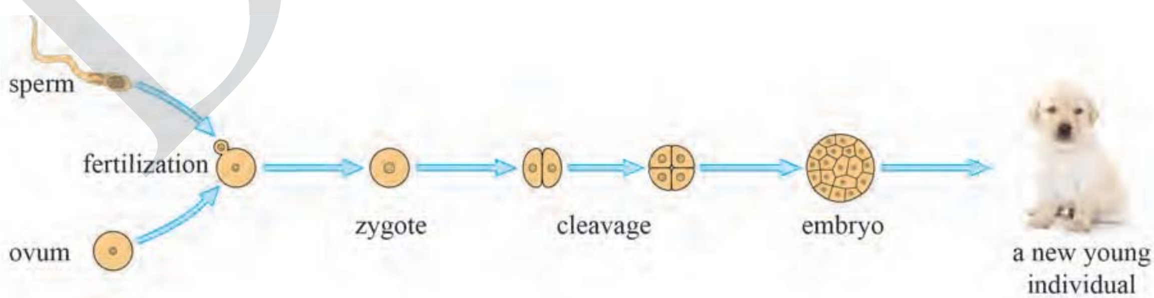


Figure 5.16 Fertilization and development of embryo and young in sexual reproduction of an animal

Sexual reproduction in humans

In humans, like in other mammals, an ovum from a female (a woman) is fertilized by a sperm from a male (a man), after sexual intercourse. This produces an embryo in the woman's uterus. After 270 days of conception which is about nine months, an embryo grows into a foetus and then a baby is born.

Female

The female reproductive organs and parts are shown in Figure 5.17 and Table 5.1.

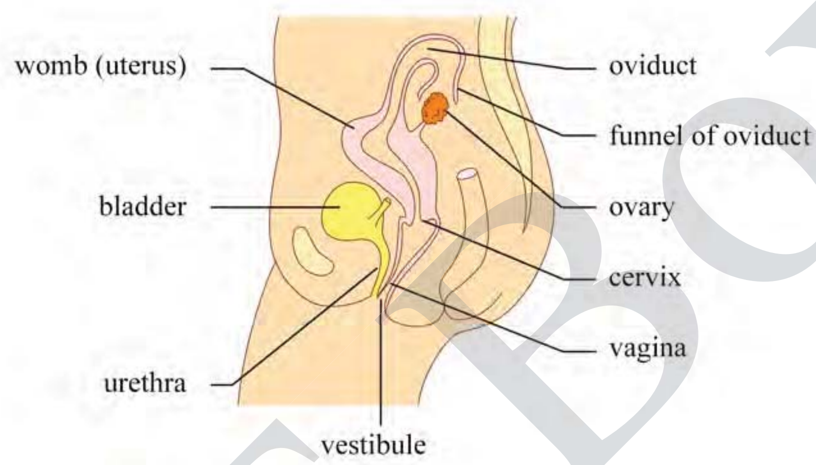


Figure 5.17 The female reproductive system in human (side view)

Table 5.1 Functions of parts of the female reproductive system in humans

Parts	Functions
Ovary	- Contains follicles in which ova (eggs) are produced
Funnel of oviduct	- Directs an ovum (egg) from the ovary into the oviduct
Oviduct	- Carries an ovum to the uterus, with propulsion provided by tiny cilia in the wall; also the site of fertilization
Uterus	- Where the foetus develops
Cervix	- A ring of muscle, separating the vagina from the uterus
Vagina	- Receives the male penis during sexual intercourse; sperm are deposited here: serves also as a birth canal
Urethra	- Carries urine from the bladder
Vestibule	- Area guarding the urethral and vaginal openings

Male

The male reproductive organs and parts are shown in Figure 5.18 and Table 5.2.

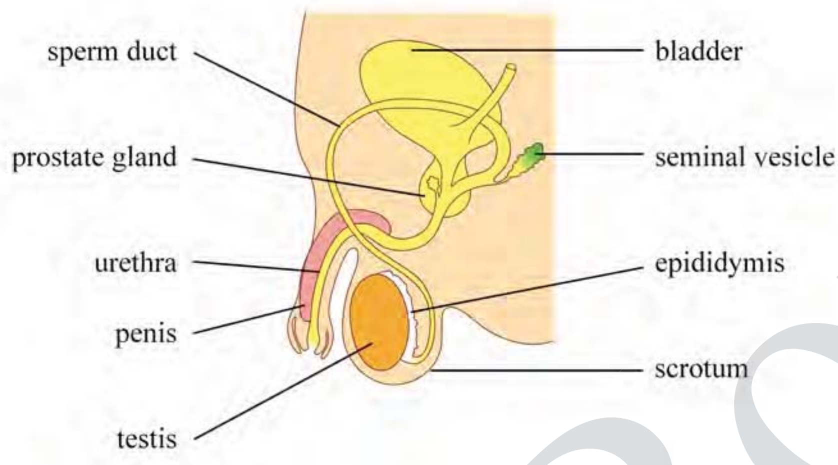


Figure 5.18 The male reproductive system in human (side view)

Table 5.2 Functions of parts of the male reproductive system in humans

Parts	Functions
Testis	- Male gonad that produces sperm
Epididymis	- A mass of tubes in which sperm are stored
Sperm duct	- Muscular tube that links the testis to the urethra to allow the passage of semen containing sperm
Seminal vesicle	- Adds fluid and nutrients to sperm to form semen
Prostate gland	- Adds fluid and nutrients to sperm to form semen
Scrotum	- A sac that holds the testes outside the body, keeping them cooler than the body temperature
Urethra	- Passes semen containing sperm through the penis; also carries urine from the bladder
Penis	- Can become firm, to insert into the vagina of the female during sexual intercourse to transfer sperm

Fertilization

Immediately after **mating** or **copulation** (sexual intercourse), the sperm swim up the uterus through the mucus lining to the oviducts (**fallopian tubes**). If there is an egg, one of the sperm may fuse with it to form a **zygote**. The process in which an egg unites with a sperm is termed as **fertilization**.

Implantation

The zygote divides continuously into a ball of cells called **embryo**. The embryo moves towards the uterus, becomes attached to the wall and is surrounded by the uterus lining. This process is termed **implantation**.

Gestation period

The period between fertilization and birth is called **gestation period** and it takes about nine months in humans. During this period, the following new structures are developed to keep the embryo alive and healthy.

Placenta - has numerous finger-like villi made up partly of embryonic tissue and partly of uterine wall (maternal tissue). The villi consist of maternal and embryonic blood **capillary** systems which are very closely associated, allowing easy diffusion of oxygen, nutrients and antibodies to the embryo and metabolic wastes from the embryo. The placenta also secretes **hormones**.

Umbilical cord - connects the embryo's body to the placenta. The two umbilical arteries and one umbilical vein are the first embryonic structures to develop. The arteries carry deoxygenated blood and excretory wastes from the embryo to the placenta. The vein carries oxygenated blood and dissolved nutrients from the placenta to the embryo.

Amnion - a sac-like membrane around the embryo, filled with a watery fluid called amniotic fluid.

Amniotic fluid - allows the embryo freedom of movement during growth and cushions it against knocks and mechanical injury (Figure 5.19).

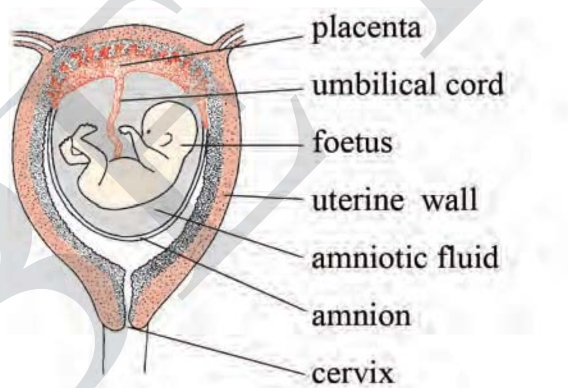


Figure 5.19 Developing foetus in human uterus

Birth

The embryo eventually develops into a **foetus**, with recognizable human features. At the end of gestation period, the muscular uterine walls begin to contract. This is termed as **labour**. The amnion bursts and the amniotic fluid is discharged. The cervix opens, and the foetus now called a baby, passes through the vagina, then out of the mother's body. This is termed birth.

Lactation and maternal care

Lactation is the process of producing milk in the mother's breasts, for feeding the baby. Breastfeeding is one of the maternal care activities.

Menstrual cycle

Ovulation occurs once in about every 28 days in woman. If the egg is not fertilized within 36 hours, it dies and the uterus lining breaks down slowly. The dead egg together with the uterus lining, mucus and some blood are discharged through the vagina. This period of bleeding is termed as **menstruation**. Ovulation does not occur during pregnancy. Therefore, menstruation ceases once a woman is pregnant until after the baby is born.

5.2 INHERITANCE

Inheritance is the transmission of genetic information from generation to generation. Plants and animals inherited certain characteristics such as plant height, fruit colour, seed shape, skin colour and eye colour. The inheritance of such characteristics is called **heredity**. Heredity is the passing of traits from parent to offspring. The branch of biology that studies how heredity works is **genetics**.

5.2.1 Nature of Chromosomes, Genes and DNA

Chromosome

Chromosome is an organized package of DNA found in nucleus of the cell.

Structure of chromosome

Each **chromosome** is made up of DNA and proteins. It can be seen at the time of cell division. Each chromosome has certain characteristics when it is ready to divide. It becomes two chromatids, joined at one point called a **centromere**. Each chromatid is a string of genes, coding for the person's characteristics. The other chromatid carries the same genes in the same order. Genes are segments of DNA (Figure 5.20).

A human body (somatic) cell nucleus contains 23 pairs of chromosomes. These are difficult to distinguish in the nucleus, so biologists separated and arranged them by sizes and appearances. This arrangement is called a **karyotype** (Figure 5.21).

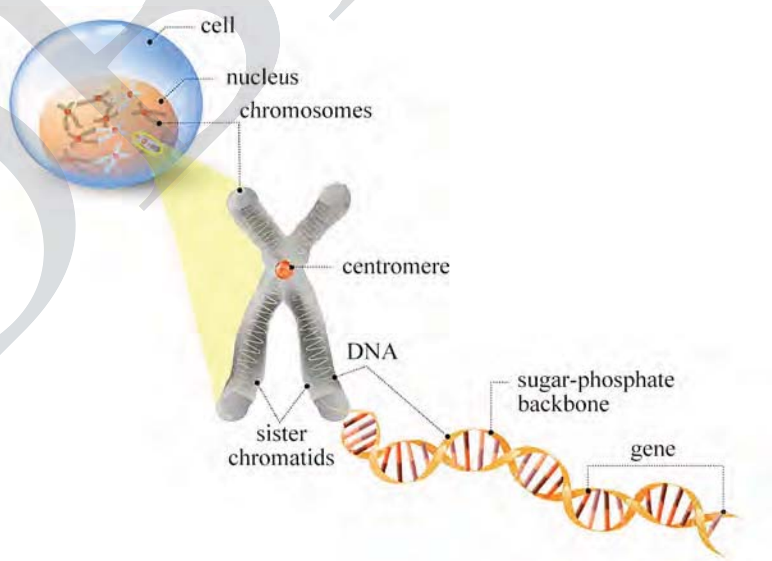


Figure 5.20 Nature of chromosomes, genes and DNA

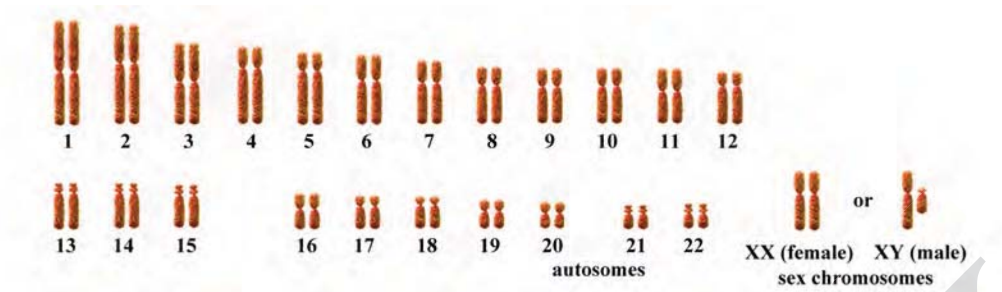


Figure 5.21 Human karyotype

Number of chromosomes

There is a **fixed number** of chromosomes in each cell of the same species. In human body cells, each contains 46 chromosomes, mouse cell contains 40, wheat contains 42 and garden pea contains 14. The number of chromosomes in a species is the **same** in all of its body cells. There are 46 chromosomes in each of liver cells, in every nerve cell, skin cell and so on in humans. The chromosomes are always in pairs, called **homologous chromosome**s such as two long ones, two short ones and two medium ones because one of each pair comes from the male gamete and one from the female gamete. In humans, there are 46 chromosomes in each cell which are inherited as 23 chromosomes from the mother and another 23 from the father.

Genes

The **gene** is the basic physical and functional unit of heredity. It is a length of **DNA** which consists of a specific sequence of nucleotides at a given position on a given chromosome that codes for a specific protein.

Gene locus

Each gene occupies a specific position on a chromosome called the gene locus.

Allele

One of the alternative forms of a gene. In a diploid cell, there are usually two alleles occupying the same **gene locus** of a pair of homologous chromosomes.

Deoxyribonucleic acid (DNA)

DNA is the chemical substance found in the chromosomes of the nucleus of a cell. DNA is the basis of inheritance in all organisms.

Structure of DNA

A molecule of DNA is made from two strands of nucleotides. Each nucleotide contains a nitrogenous base which is either adenine (A) or thymine (T) or cytosine (C) or guanine (G), a sugar molecule and a phosphate group (Figure 5.22).

In the two strands of DNA, nucleotides with adenine are always paired to opposite nucleotides with thymine and nucleotides with guanine to that of cytosine. Adenine and thymine are complementary bases, as are also cytosine and guanine. Complementary bases always bind with each other. They are always fixed pair. This is known as base-pairing rule. DNA can replicate itself, so replication is able to pass genetic information from one generation to the next as a genetic code (Figure 5.23).

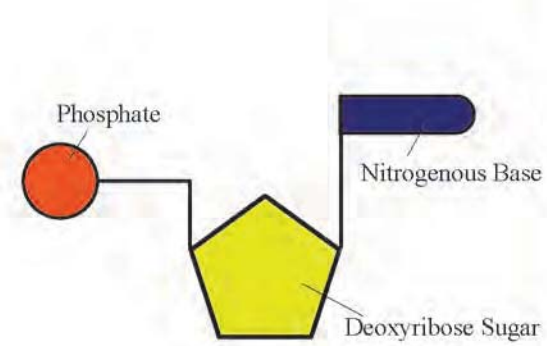


Figure. 5.22 A nucleotide of DNA

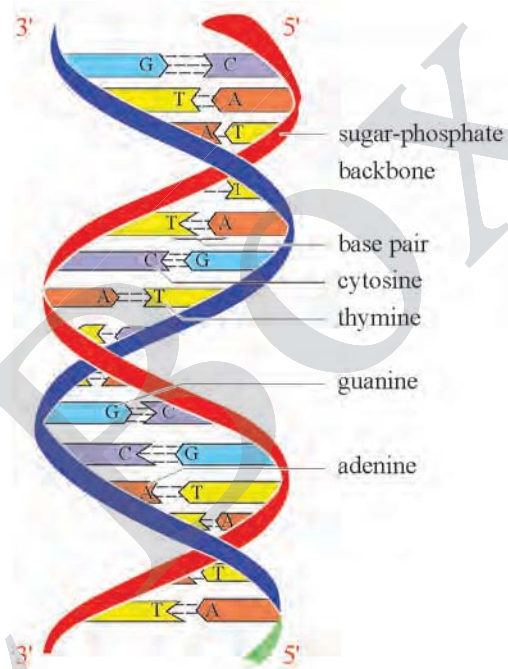


Figure 5.23 The structure of DNA

5.2.2 Cellular Reproduction

Cellular reproduction is a process by which cells duplicate their contents and then divides to produce two similar cells. It is essential to growth and development of cells.

Cell division

Every living cell is formed from a pre-existing cell by the process of cell division. Cell division consists of four stages, prophase, metaphase, anaphase and telophase. The cell cycle includes an additional stage termed interphase. Cell division in eukaryotes is the process by which a parent cell divides into two or more daughter cells. In eukaryotes, there are two distinct types of cell division; a vegetative cell division where each daughter cell is genetically identical to the parent cell i.e., same number of chromosomes (mitosis) and a reproductive cell division where the number of chromosomes in the daughter cell is reduced by half to produce haploid gametes (meiosis).

Types of cell division

Two different types of cell division in eukaryotes are mitosis and meiosis.

Mitosis

Mitosis is a process that creates a nearly exact copy of the parental cells. The mitotic cell division involves mitosis and cytokinesis. Mitosis is the division of the nucleus and results into two identical daughter nuclei. Cytokinesis is the division of the cytoplasm into two cells. After mitosis and cytokinesis, two diploid daughter cells which are genetically identical to the diploid parent cells (Figure 5.24).

Meiosis

Meiosis is a different form of cellular reproduction that leads to germ cells or sex cells. It consists of two stages: Meiosis I and Meiosis II. Meiosis I is the first cell division, results into two haploid cells and meiosis II is the second cell division, results into four haploid cells. This type of cell division is called reduction division because they contain half the number of chromosomes of the diploid parent cells (Figure 5.25).

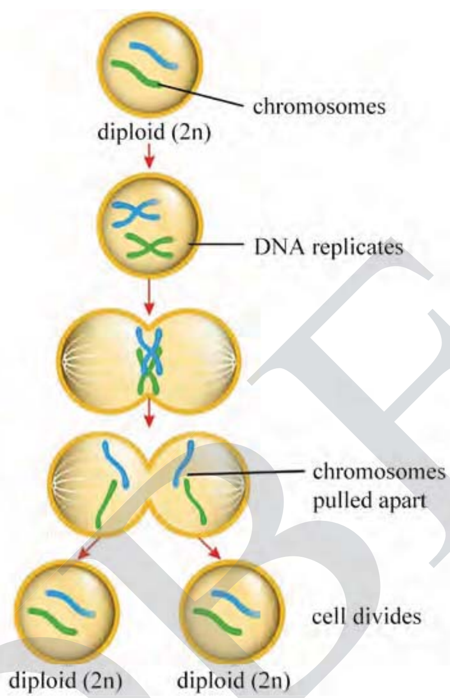


Figure 5.24 Mitosis

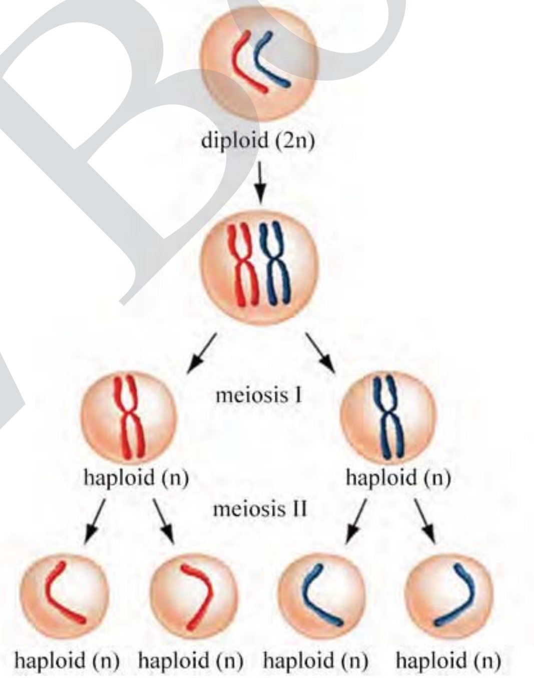


Figure 5.25 Meiosis

Importance of mitosis

Mitosis produces two daughter cells with the same identical genetic components (chromosomes) as the parent cell. Mitosis is important to regulate the cell growth, development and repair in multicellular organisms.

Importance of meiosis

Meiotic cell division produces four haploid sex cells from existing diploid cell and therefore it creates genetic variation. Meiosis is nature's way of keeping the chromosome number constant from generation to generation.

Table 5.3 Mitosis versus meiosis

Facts	Mitosis	Meiosis
Type of reproduction	- Asexual	- Sexual
Occurs in	- All eukaryotes	- Humans, animals, plants, fungi
Genetically	- Identical to parent cell	- Different from parent cell
Function	- Cellular reproduction, general growth, repair of the body and clone production	- Genetic diversity through sexual reproduction
Chromosome number	- Remain the same as in parent cell	- Reduce by half of parent cell
Creates	- New cells other than sex cells	- Sex cells only: female egg cells or male sperm cells

5.2.3 The Role of Cellular Reproduction in Multicellular Organisms

In multicellular organisms, the cellular reproduction (cell division) is important for the following purposes.

1. Growth – The cells in meristematic tissues of multicellular plants divide throughout life for growth in length and girth, while growth in animal cells increases in number by mitotic cell division.
2. Healing of wounds – In both plants and animals, cells divide to heal the wounds. It is an occasional event by mitosis.
3. Reproduction – Sex cells of both plants and animals divide meiotically during the reproductive age.
4. Stem cells – In animals, after mitotic cell division, some cells become specialized but some become stem cells which are able to divide for continuous growth of the animals. But specialized cells cease to divide.

5.2.4 The Role of Chromosomes and Genes in Inheritance

Heredity is the transfer or passing of characteristics genetically from the parents to the offspring.

The genetic information is carried within chromosomes. The chromosomes are found in the nucleus of a cell. Long coiled molecules of DNA make up chromosomes. The genes are contained in the DNA. They are the units of heredity and are responsible for inheritance. Information for the expression of characteristics is contained in genes. Different traits are formed by different genes. The gene carries the genetic code for a particular characteristic. e.g., the height of a person or the facial features such as nose or jawline are all controlled by different genes.

The inheritance of characteristics in an organism is contributed equally by the mother and father. The mother and father provide equal amounts of genetic material to their offspring. Therefore, each trait has two factors, one that comes from the mother and the other that comes from the father.

Most of the genes have more than two variations, they are called alleles. e.g., there are two alleles for the height gene, one is short and one is tall. The offspring may inherit the same alleles from both parents or two different alleles from them. When the offspring inherits two different alleles then it interacts in a particular way. There is a dominant trait and a recessive trait.

The dominant trait comes from an allele of the gene that decides the trait in the presence of the other recessive allele of the identical gene. The trait that does not get to express itself is called the recessive trait.

Genetics

Genetics is the study of heredity and variations of inherited characteristics, and the way that characters are passed on from one generation to the next.

Character

A distinctive inherited feature of an organism

Trait

Different variations of a character

Variation

Variation is the differences in characters between the individuals of the same species.

Dominant trait

The trait is expressed in an organism, suppressing the recessive trait. The dominant trait is denoted using capital letters.

Recessive trait

The trait stays suppressed or cannot be expressed in the presence of the dominant trait. The recessive trait is denoted using small letters.

Dominant allele

An allele carries the dominant trait and is expressed in the phenotype of the organism. For example, the dominant trait tall is represented by **T**.

Recessive allele

An allele carries the recessive trait and is only expressed as the phenotype of the organism in the absence of the dominant allele. For example, the recessive trait short or dwarf is represented by **t**.

Genotype

The genetic constituents of an organism, i.e., the different alleles of different traits present in a gene. That is **TT** or **Tt** for tall genotypes, **tt** for short or dwarf genotype.

henotype

The observable characteristics of an organism are determined by the specific genotype. That is whether the plant is tall, short, with white flowers or red ones, etc.

omo ygote

An individual contains only one allele of the allelic pair. Alleles that form the homo ygous allelic pair are the same (e.g., TT). A homo ygote produces only one ind of gamete.

etero ygote

An individual contains one of each member of the allelic pair. Alleles that form the heterozygous allelic pair are different (e.g., Tt). A heterozygote produces different kinds of gamete.

ure reeding plants

Those plants when self-fertilized, produce identical offspring generation after generation.

ure line animals

ating se ually between the homo ygous individuals (male and female) produces individuals of pure line with same genetic identity for many generations.

atterns of inheritance

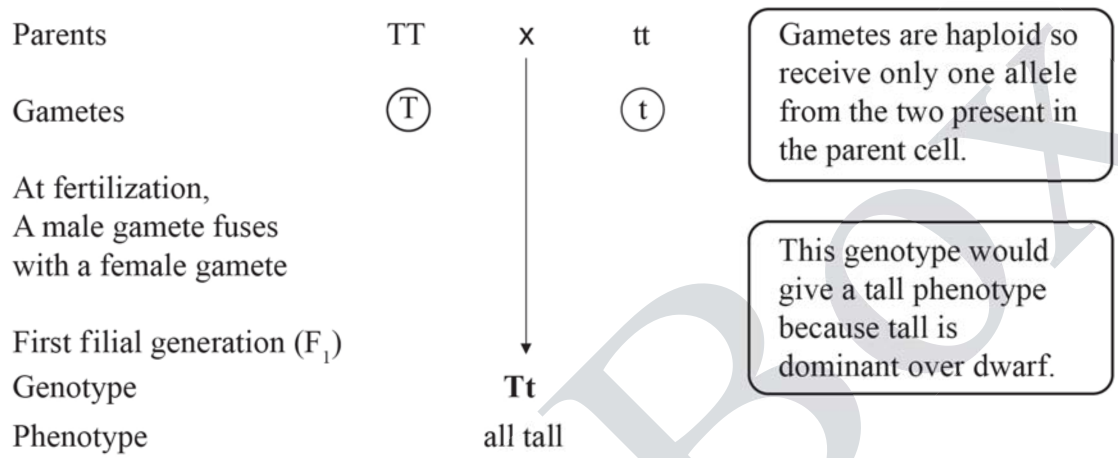
The breeding e periments are carried out to study the inheritance of characteristics in se ually reproducing plants and animals. There is a general pattern for describing the results of e periments. At fertili ation, male gamete fuses with female gamete to produce offspring or progeny. In writing the stages of a cross, chromosomes and genes are replaced by using sym ols that should be identified at the start of a cross.

For e ample onohybrid crosses

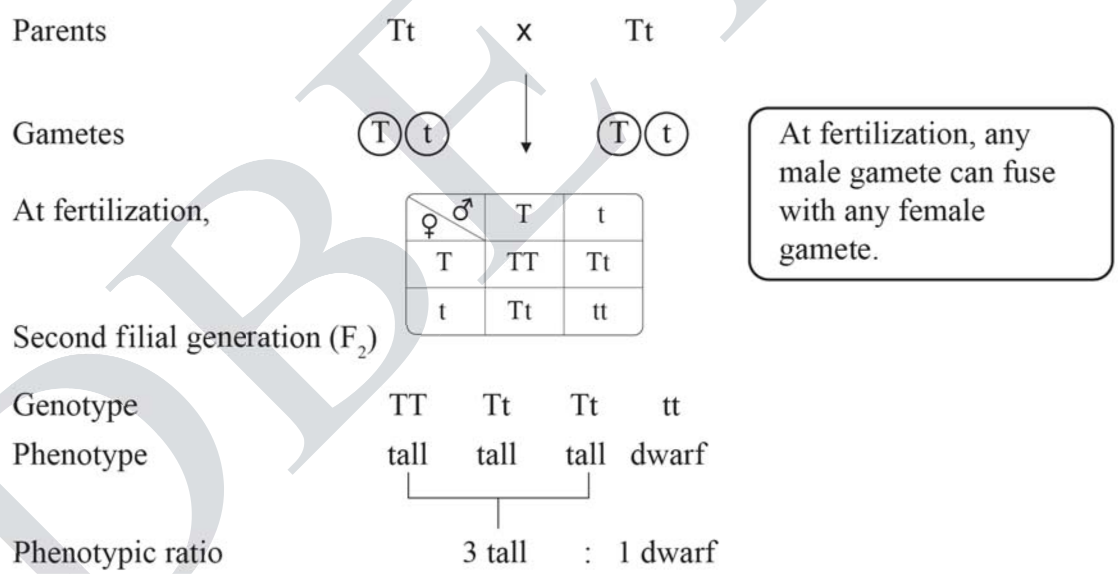
et T tall allele and t dwarf or short allele for height

The capital letter is used for dominant allele and small letter is used for recessive allele. Tall T and dwarf t are alleles for pea plant height.

- A cross between a homo ygous tall (TT) and a homo ygous dwarf (tt) parents



- A cross between a hetero ygous tall (Tt) and a hetero ygous tall (Tt) parents from F

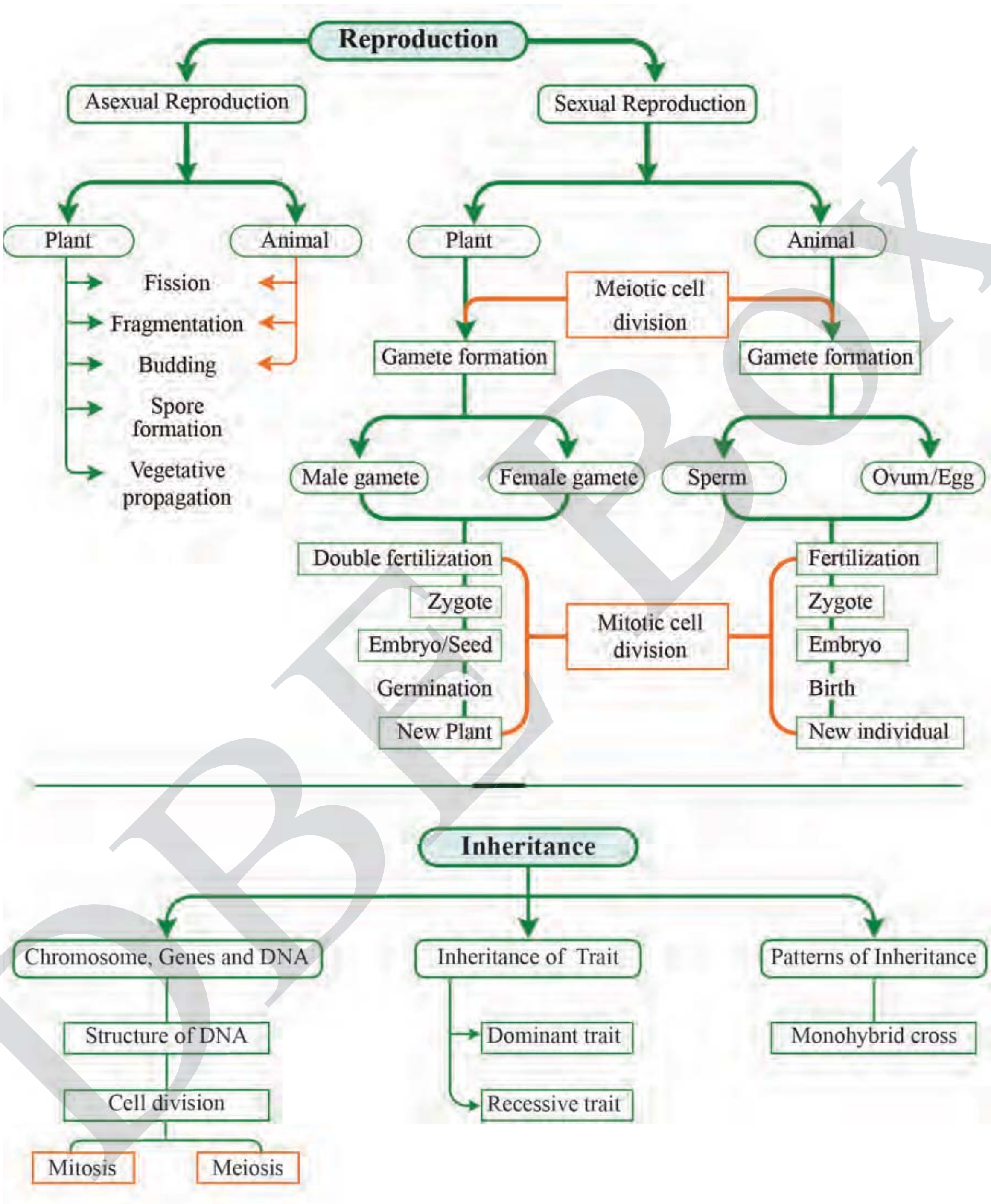


These results are possibilities (chances). In the second cross, the offspring may be in the 3 ratio but each fertili ation is random so that the ratio may vary. In theory, a cross between two heterozygous parents should produce offspring in the ratio of 3:1 (3 dominants: 1 recessive). This result can be restated as the probability of any offspring showing dominant height (tall) is 3 or 5 and recessive (dwarf) is or 25 .

Revie uestions

. numerate the types of ase ual reproduction in plants and e plain any two with appropriate diagrams.
2. Define the term vegetative propagation with e amples.
3. plain how the bud grafting is carried out in plants with a suitable diagram.
. hat happens to the pollen grain before and after pollination
5. Describe the process after pollination in plants.
6. Name the different types of reproduction in animals.
. tate the parts and functions of female reproductive system in human.
. Describe the parts with related functions in male reproductive system of human.
. ow many chromosomes would be in the nucleus of
(a) human muscle cell
(b) a mouse idney cell
(c) human s in cell
(d) human sperm cell
. ow many chromosomes would be present in
(a) a mouse sperm cell
(b) a mouse ovum
. hat is the basic unit of heredity
2. hat are the components of a nucleotide
3. Name the nitrogenous bases in DNA.
. DNA e ists as a double heli . Name the base pairs that hold the double heli together.
5. ow many stages are involved in mitosis
. Compare the meiotic and mitotic cell divisions with diagrams.
. Compare the significance of mitosis versus meiosis.
18. In pea plants, there are two different heights: tall or dwarf. This characteristic is controlled by one pair of genes. Tall is dominant over dwarf. Choose the suitable letters for the gene pair.

Concept map


Reproduction
Asexual Reproduction
Sexual Reproduction
Plant
Animal
Fission
Fragmentation
Budding
Spore formation
Vegetative propagation
Plant
Animal
Meiotic cell division
Gamete formation
Gamete formation
Male gamete
Female gamete
Sperm
Ovum/Egg
Double fertilization
Zygote
Embryo/Seed
Germination
New Plant
Mitotic cell division
Fertilization
Zygote
Embryo
Birth
New individual
Inheritance
Chromosome, Genes and DNA
Inheritance of Trait
Patterns of Inheritance
Structure of DNA
Cell division
Mitosis
Meiosis
Dominant trait
Recessive trait
Monohybrid cross