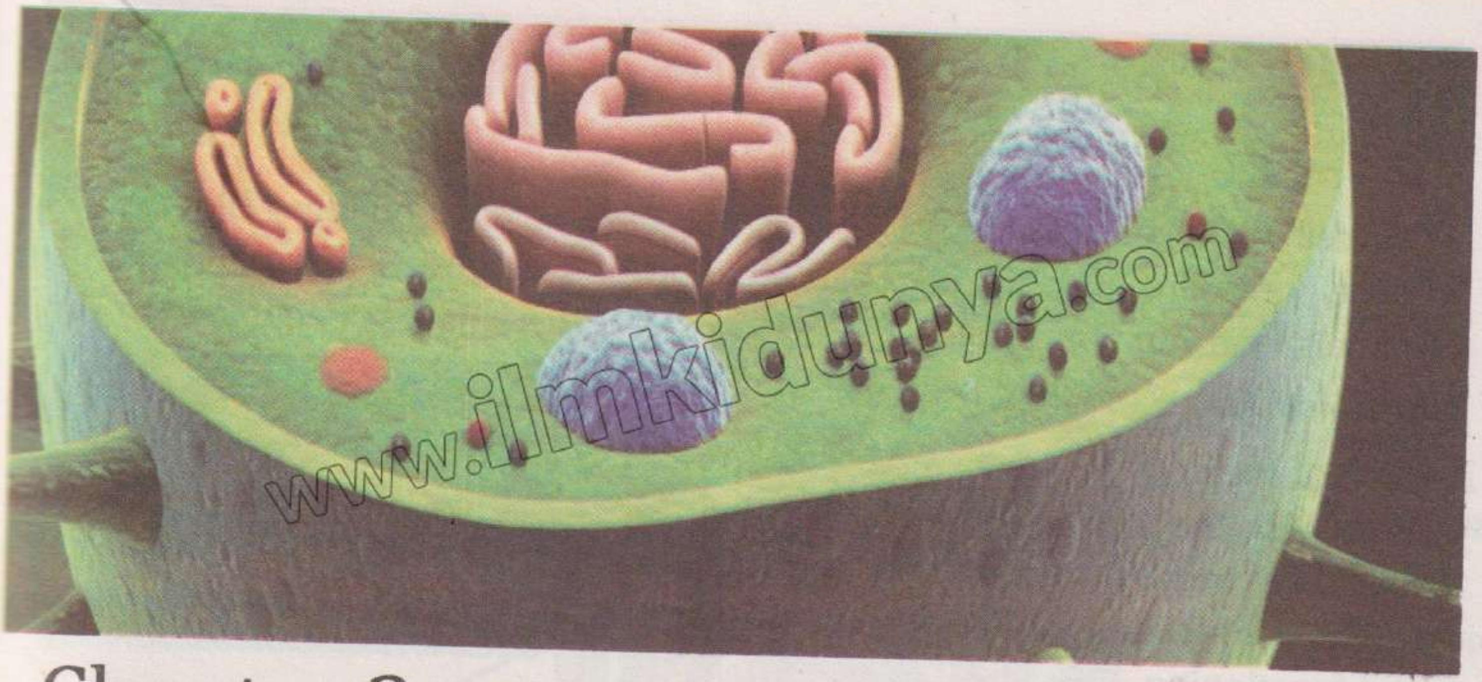


Chapter 3

THE CELL

After studying this chapter, students will be able to:

- Describe cell as the basic unit of life.
- Compare with diagrams the structure of animal and plant cells.
- Sketch different sub-cellular organelles and outline their roles.
- Identify different types of cells (mesophyll cell, epidermal cell, neurons, muscle, red blood
- cell, liver cell) and sketch their structures.
- Describe the concept of division of labour and how it applies within cells (across organelles) and in multicellular organisms (across cells)
- Describe cell specialization.
- Define stem cells as unspecialized cells.

Have you ever wondered which tiny building blocks make up all living things? Cells are the microscopic structures that form the foundation of life. Cells are the units that carry out all the functions necessary for life. In this chapter, we will explore the fascinating world of cells, uncovering their intricate structures and vital roles in the living world.

Cell is like a City

A cell is like a busy city. For example, in a cell there are structures that produce energy (like power plants of the city), some structures process and transport materials (like roads and delivery services), and other structure remove or break wastes (like waste disposal units). Finally, just like a city has a government, a cell has a nucleus that directs its activities, by giving instructions for every function of the cell.

3.1- CELL

The cell is the basic unit of life. Just as bricks are the building blocks of a house, cells are the building blocks of living organisms, including plants, animals, and humans. Every living thing, from the smallest bacterium to the largest whale, is made of cells.

Most of the cells are very small, and cannot be seen with the naked eye. Despite their size, cells are very complex and carry out all essential functions to keep living things alive and functioning.

Some cells are large enough to be seen with naked eye e.g., the egg cell of ostrich, a unicellular green algae *Acetabularia*, and a unicellular giant *Amoeba*.

3.2- STRUCTURE OF CELL

The basic structure of a cell was discovered by an English scientist Robert Hooke. In 1665, using a simple microscope, Hooke examined a thin slice of cork and discovered tiny, box-like structures that he called "cells." He could not study the details of the internal structure of cell. However, in the 19th century the quality of microscope improved. In 1831, while studying plant cells under a microscope, a Scottish scientist, Robert Brown observed the "nucleus". After that, many organelles were discovered in coming years. In the following paragraphs we will study the structures present in cells and their functions.

There are two basic types of cells: prokaryotic and eukaryotic. Prokaryotic cells are simple and do not have membrane-bound organelles. Eukaryotic cells are more complex and have membrane-bound organelles.

Cell Wall

The cells of bacteria, fungi, plants and some protists (algae) have a rigid non-living wall around cell membrane. It is called cell wall. It provides shape, strength, protection and support to the inner living matter (protoplasm) of the cell. The plant cell wall is made of three layers i.e., middle lamella, primary wall, and secondary wall.

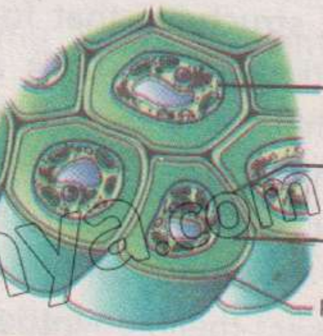


FIGURE 3.1: Layers of plant cell wall

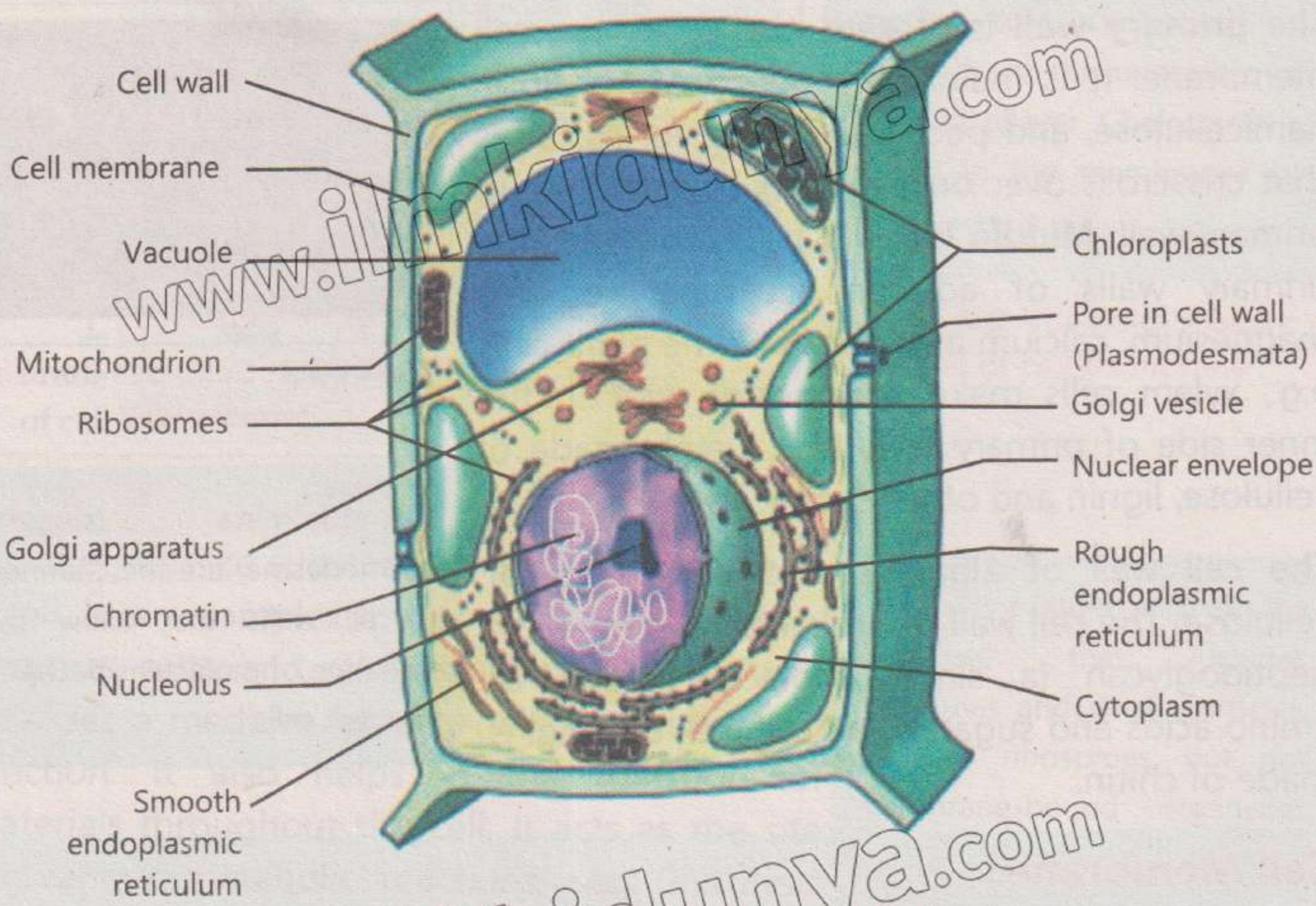


FIGURE 3.2: Structure of a plant cell

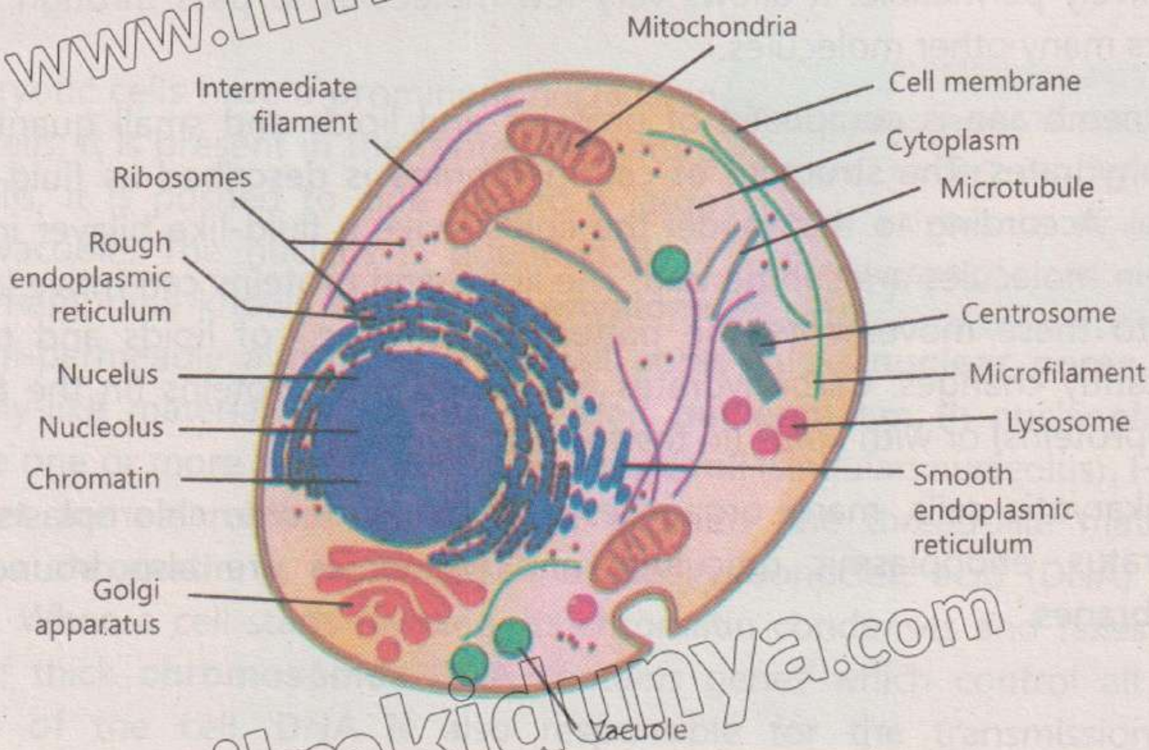


FIGURE 3.3: Structure of an animal cell

The **primary wall** is present just above the cell membrane. It is mainly composed of cellulose, hemicellulose, and pectin. Cellulose forms fibres that crisscross over one another to form strong primary wall. **Middle lamella** holds together the primary walls of adjacent cells. It contains magnesium, calcium and pectin. Some plant cells e.g., xylem cells make **secondary wall** on the inner side of primary wall. It is mainly made of cellulose, lignin and other chemicals.

FIGURE 3.4: Cellulose fibresin primary wall

Plasmodesmata (singular plasmodesma) are the channels in cell walls that allow the exchange of molecules between adjacent cells.

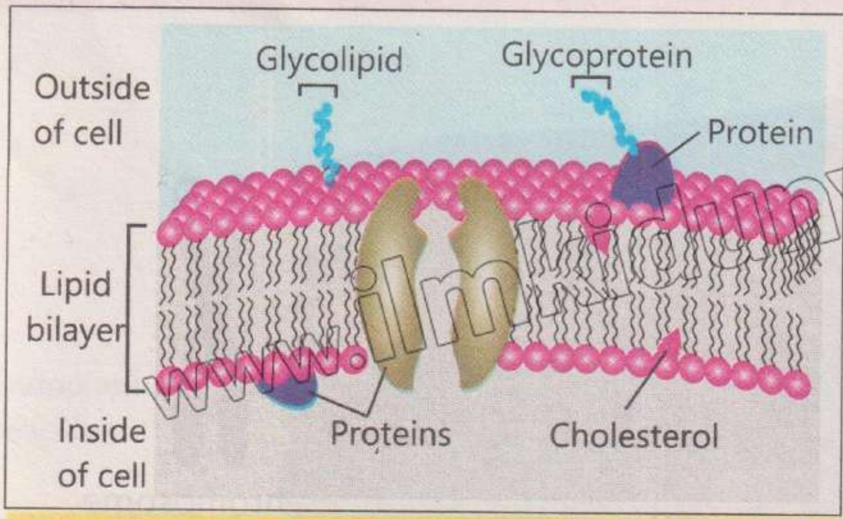
The cell wall of algae is also composed of cellulose. The cell wall of prokaryotes is made of peptidoglycan (a single molecule made of amino acids and sugars). The cell wall of fungi is made of chitin.

Cell Membrane

All cells have a thin and elastic cell membrane around the cytoplasm. It is selectively-permeable. It allows very few molecules to pass through it while blocks many other molecules.

Cell membrane is composed of proteins and lipids and small quantities of carbohydrates. The structure of cell membrane is described as fluid-mosaic model. According to this model the lipids make a fluid-like bilayer in which protein molecules are submerged. The lipids and proteins can move laterally. Due to these movements, the pattern or "mosaic," of lipids and proteins constantly changes. Carbohydrates are joined with proteins (in the form of glycoproteins) or with lipids (in the form of glycolipids).

In eukaryotic cells, many organelles e.g., mitochondria, chloroplasts, Golgi apparatus, endoplasmic reticulum, and lysosomes are also bounded by membranes.



Another lipid, cholesterol, is attached with the inner sides of the lipid bilayer. Cholesterol is absent in the membranes of most bacteria.

FIGURE 3.5: The fluid- mosaic model of cell membrane

Cytoplasm

It is the jelly-like substance that fills the inside of a cell. It is a complex mixture of water, proteins, enzymes, salts, and other substances. Cytoplasm provides a medium for organelles to move and function. It also helps in the transport of materials throughout the cell. It acts as the site for various metabolic reactions e.g., Glycolysis (breakdown of glucose). It also stores food and wastes of the cell.

Cytosol is a liquid part of the cytoplasm that includes molecules and small particles, such as ribosomes, but not membrane-bound organelles.

Nucleus

All eukaryotic cells have a prominent nucleus. In animal cells, it is present in the center. In mature plant cells, it is pushed to side due to a large central vacuole. The nucleus is bounded by a double membrane known as **nuclear envelope.** It is semi-permeable and has many small pores called **nuclear pores.** The inner jelly-like material of nucleus is called **nucleoplasm.** In nucleoplasm, there are one or more small bodies called **nucleoli** (singular; nucleolus). Here, ribosomes are assembled. Nucleoplasm contains fine thread-like material known as **chromatin**. It is composed of deoxyribonucleic acid (DNA) and proteins. When a cell starts dividing, its chromatin condenses and takes the shape of thick **chromosomes.** DNA contains genes which control all the activities of the cell. DNA is also responsible for the transmission of characteristics to the next generation. That is why it is called the hereditary material.

The nucleus serves as the cell's "control center". It oversees cellular activities by directing the production of proteins.

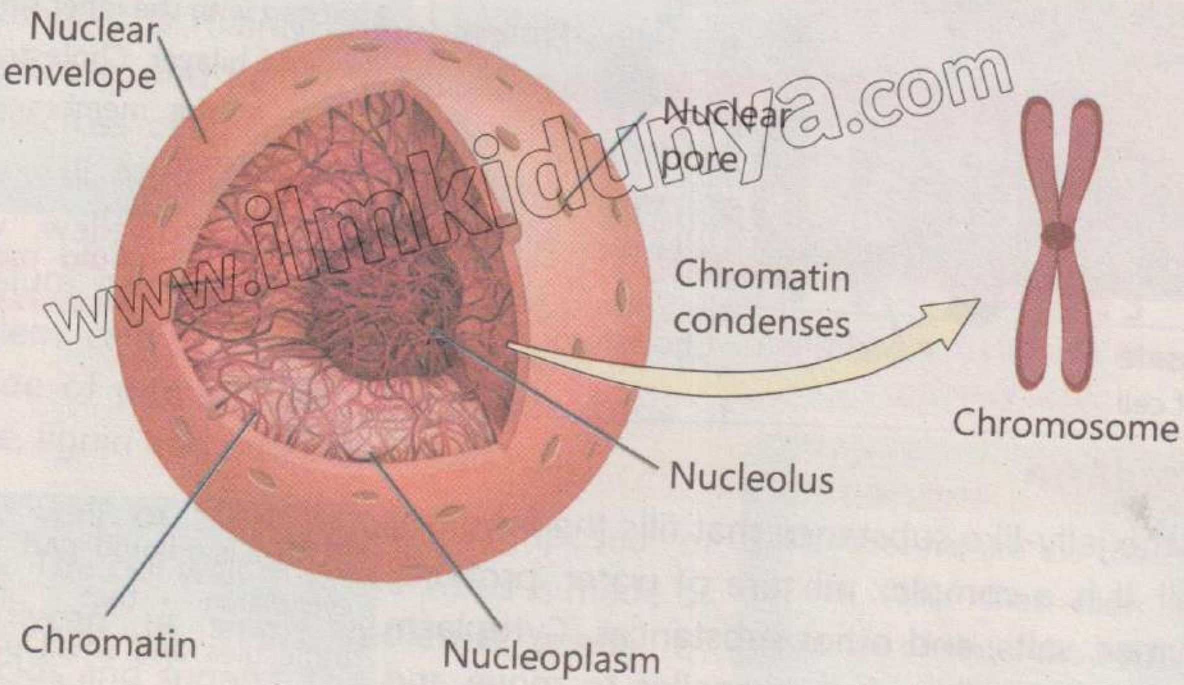


FIGURE 3.6: Structure of Nucleus and chromosome

The prokaryotic cells do not contain a prominent nucleus. Their chromosome is made of DNA only and floats in cytoplasm.

Cytoskeleton

It is a network of thin tubes and filaments present throughout the cytoplasm. It consists of three parts i.e., microtubules, microfilaments, and intermediate filaments.

Microtubules are hollow tubes made up *tubulin* protein. This part holds organelles in place, maintains a cell's shape, and act as tracks for organelles. Microtubules also make mitotic spindle, cilia and flagella.

Microfilaments are finer than microtubules. These are made up of contractile proteins mainly *actin*. They help in cell movement e.g., the crawling of white blood cells and the contraction of muscle cells.

Intermediate filaments are rods made of variety of proteins, mainly *keratin* and *vimentin*. They anchor the nucleus and some other organelles in the cell. They also make cell-to-cell junctions.

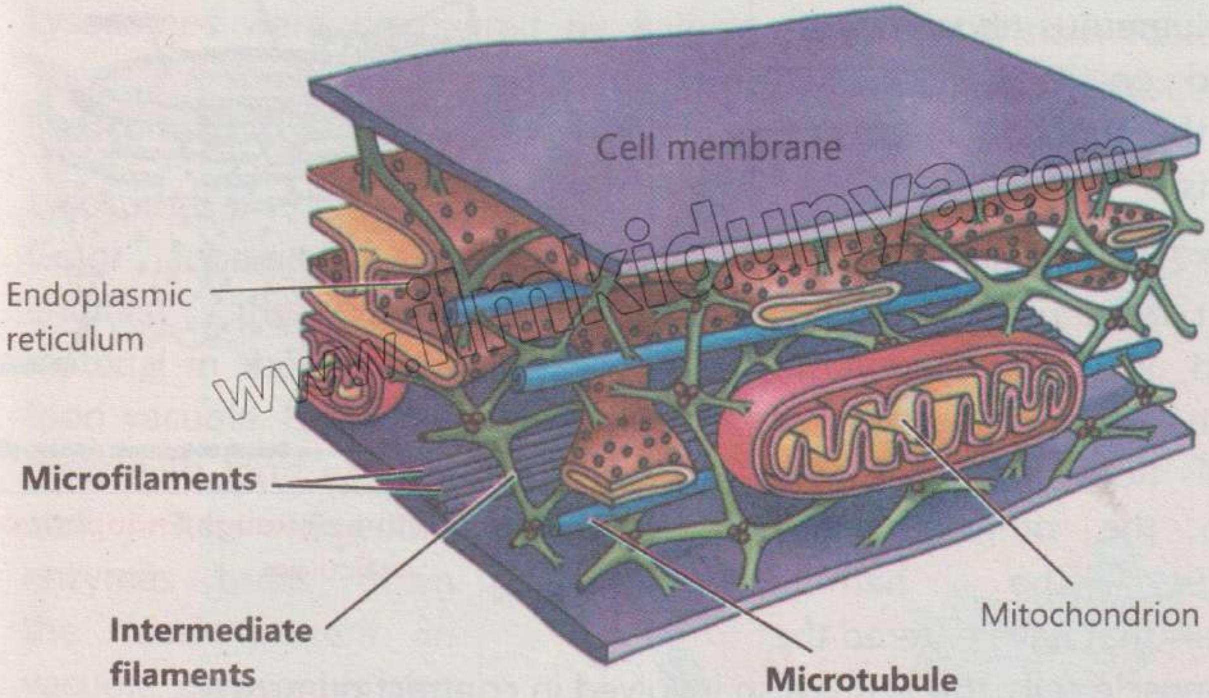


FIGURE 3.7: Cytoskeleton

Ribosome

Ribosomes are tiny granular structures. They are the sites of protein synthesis. Ribosomes float freely in the cytoplasm and are also attached on the surface of rough endoplasmic reticulum. They are composed of almost equal amounts of proteins and ribosomal RNA (rRNA). Ribosomes are not bounded by membranes and so are also found in prokaryotes. Eukaryotic ribosomes are slightly larger than prokaryotic ones. Each ribosome consists of two subunits. The two subunits of a ribosome unite during the process of protein synthesis. When a ribosome has finished its work, its subunits get separated again.

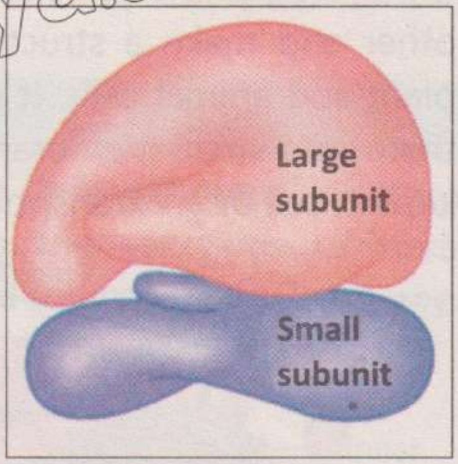


FIGURE 3.8: Ribosome

Endoplasmic Reticulum

It is a network of membrane-bounded channels present throughout the cytoplasm of eukaryotic cell. There are two types of endoplasmic reticulum.

Rough Endoplasmic Reticulum (RER): Numerous ribosomes are attached on its surface. RER serves the function in protein synthesis.

Smooth Endoplasmic Reticulum (SER): It lacks ribosomes. It is involved in lipid metabolism and in the transport of materials from one part of the cell to the other. It also detoxifies the harmful chemicals that have entered the cell. In muscle cells, the SER is also involved in contraction process.

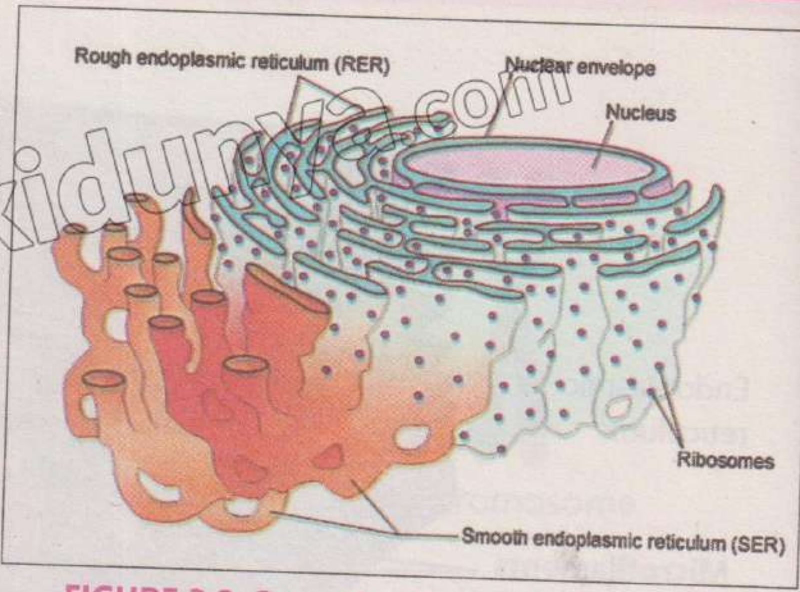


FIGURE 3.9: Smooth and Rough Endoplasmic Reticulum

Golgi Apparatus

In 1898, an Italian physician Camillo Golgi discovered a set of flattened sacs in the cytoplasm. These flattened sacs, called **cisternae** are stacked over each other and make a structure known as Golgi apparatus. It is found in both plant and animal cells. It modifies proteins coming from rough ER and packs them into small membrane-bound sacs called **Golgi vesicles**.These sacs are kept in cell or are transported to exterior in the form of secretions.

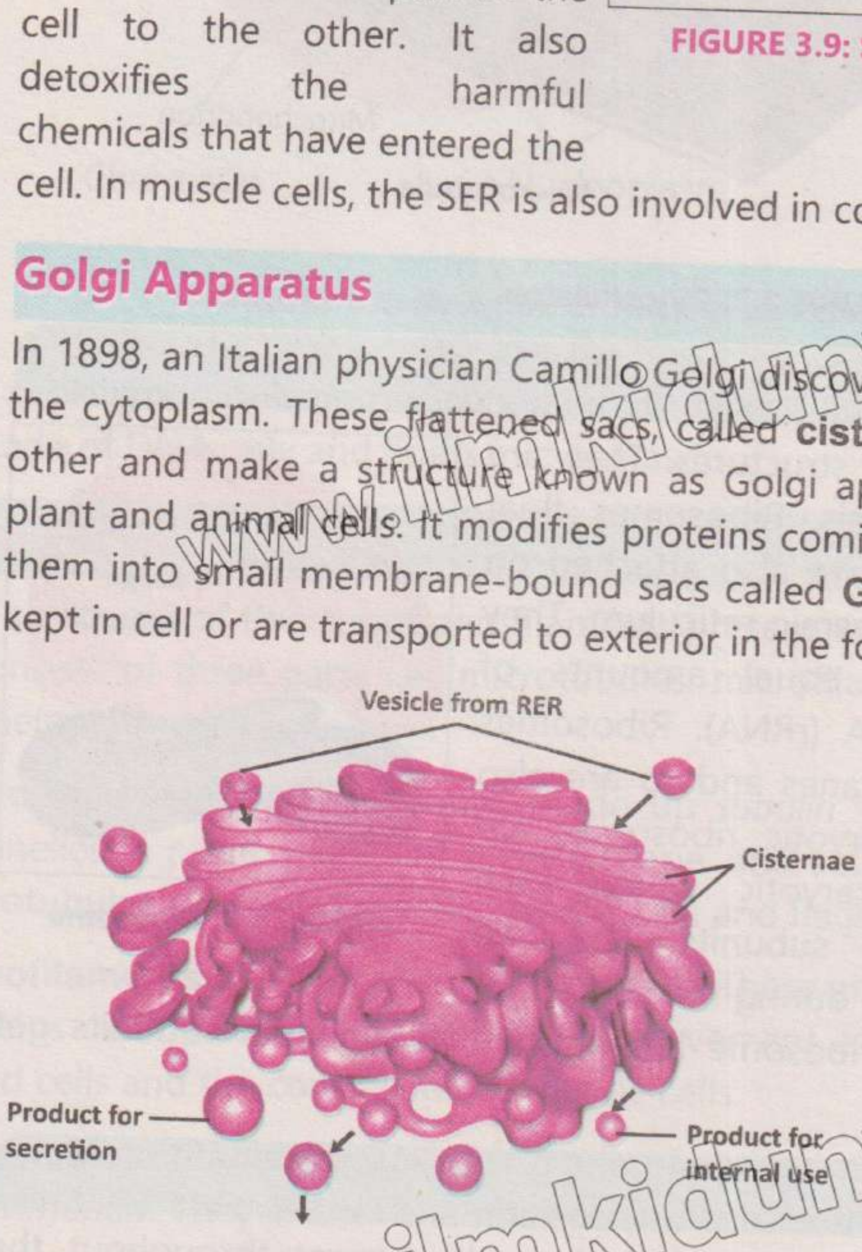


FIGURE 3.10: Golgi apparatus

In 1906, Golgi was awarded Nobel Prize for physiology and medicine.

Lysosome

Lysosomes were discovered by Belgian scientist Christian René de Duve. These are small membrane-bound vesicles that contain digestive enzymes. Lysosomes are predominantly found in animal cells.

Lysosomes bud off from Golgi apparatus. Cell engulfs the food material in the form of food vacuole. Lysosome fuses with food vacuole and its digestive enzymes break down the food present in vacuole. Lysosomes also have enzymes for breaking cellular wastes. They also engulf the damaged organelles and break them. Lysosomes can store certain molecules for later use.

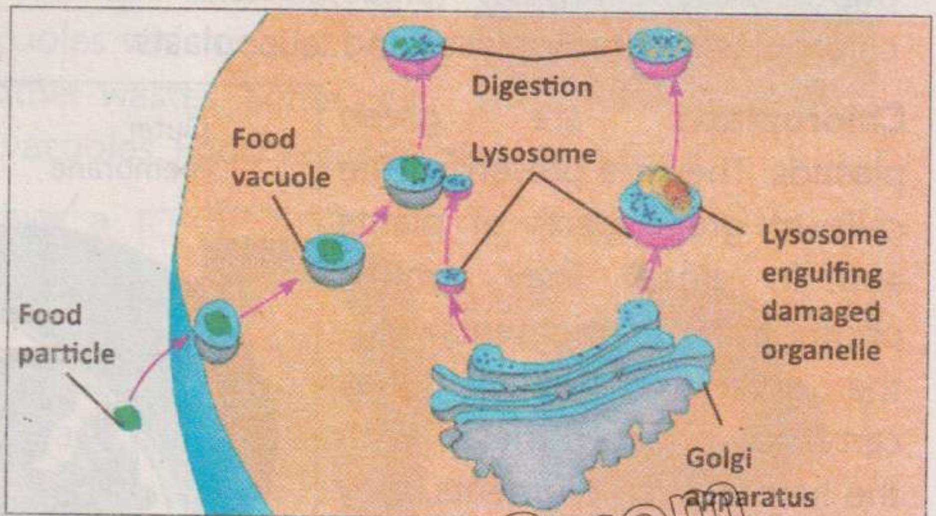


FIGURE 3.11: Formation and function of Lysosome

Mitochondria

Mitochondria (singular: mitochondrion) are the **"powerhouse"** of the cell because they produce energy. They perform the reactions of aerobic respiration in which oxygen is used to break food (glucose) to release energy in the form of ATP.

Mitochondria are double membrane-bounded organelles present only in eukaryotes. The outer membrane of mitochondria is smooth but the inner membrane forms many folds. These folds are called **cristae** (singular crista). They increase the surface area for respiration. The inner fluid-like material is called **matrix**. Mitochondria contain

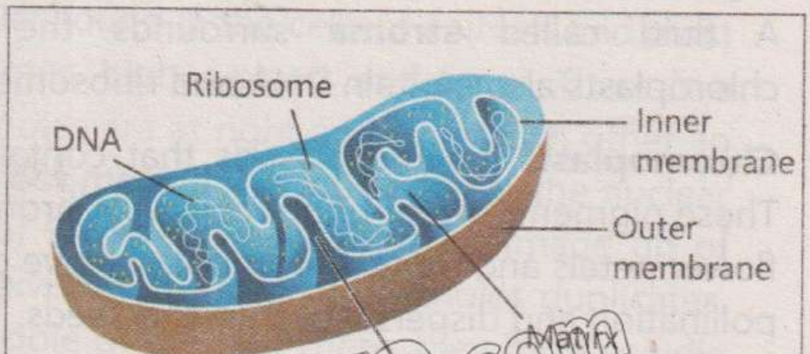


FIGURE 3.12: A Mitochondrion

their own DNA and ribosomes. The ribosomes of mitochondria are more similar to prokaryotic ribosomes than to eukaryotic ribosomes.

Plastids

Plastids are membrane-bounded organelles present in the cells of plants and photosynthetic protists (algae). There are three main types of plastids: chloroplasts, chromoplasts, and leucoplasts.

Chloroplasts are green plastids. They are present in the cells of green parts of plants and in algae. They contain photosynthetic pigments e.g., the green chlorophyll. They carry out photosynthesis. With the help of their pigments, they capture light energy and convert it into chemical energy. They use this energy to prepare glucose.

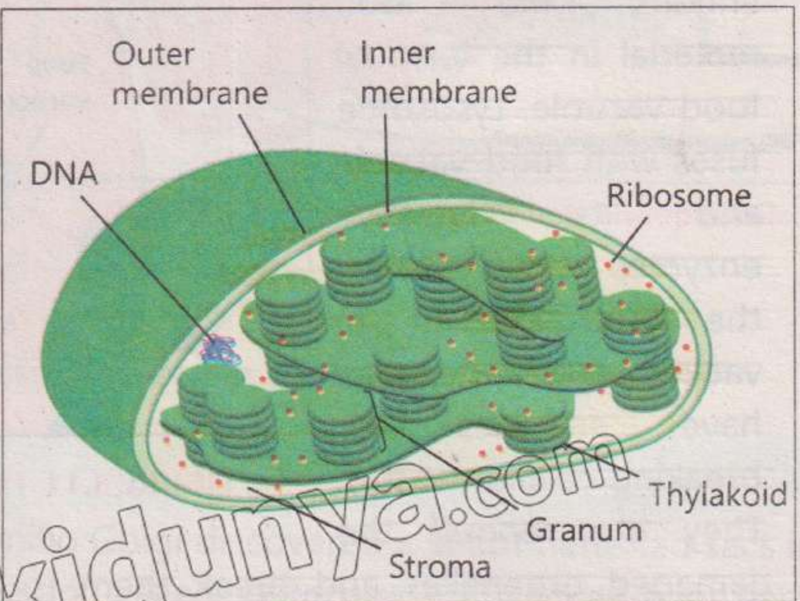


FIGURE 3.13: A Chloroplast

Like mitochondria, chloroplasts are enclosed by double membrane. On the internal side of inner membrane, there are many sets of stacked membranes. These stacks are called **grana** (singular, granum). The sac-like structures which make a granum are called **thylakoids**. Photosynthetic pigments are present on the surface of thylakoids. A fluid called **stroma** surrounds the thylakoids. Like mitochondria, chloroplasts also contain DNA and ribosomes.

Chromoplasts are the plastids that contain pigments such as carotenoids. These pigments are of bright colours. Chromoplasts are present in the cells of flower petals and fruits. Chromoplasts give colours to these parts, thus help in pollination and dispersal of fruit and seeds.

Leucoplasts are plastids that have no pigments. They are involved in the storage of starches, lipids, and proteins. They are present in the cells of those parts of plants where food is stored e.g., underground stems, seeds, roots etc.

Vacuoles

These are single membrane-bound sacs filled with fluid. Animal cell may have many small temporary vacuoles. They contain water and food substances. Some freshwater organisms like amoeba and sponges have contractile vacuoles which collect and pump out extra water and other wastes. Some cells ingest food by forming food vacuoles. Food vacuoles also store food.

Point to ponder!

Why are the vacuoles called the wastebins of the cells?

Most mature plant cells have a single, large, central vacuole. It is formed by the fusion of many small vacuoles. The membrane of plant vacuole is called tonoplast and the sap inside plant vacuole is called cell sap. It is a watery solution of salts. Due to this large central vacuole, the nucleus is pushed to a side. This outward pressure of the vacuole on the cytoplasm and cell wall makes plant cells turgid. This pressure is called **turgor pressure** and the process is called **turgor**. The turgor pressure helps in maintaining the shape of cells.

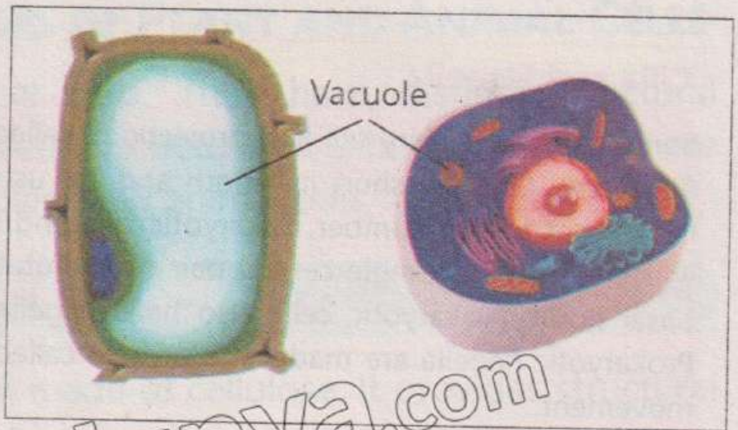


FIGURE 3.14: Vacuole in plant and animal cell

Centrioles

Centrioles are barrel-shaped organelles found in the cells of animals and most protists. They are absent in prokaryotes, higher plants and fungi. There is a pair of centrioles in which both centrioles are at right angles to each other. In animal cells, the pair is called a **centrosome** and it is located near the nuclear envelope. Each centriole is formed of 9 triplets of microtubule (made up of tubulin protein). At the start of cell division, the pair of centrioles duplicates. The new pairs move to the opposite pole of the cell. There, they form spindle fibres, which are responsible for the separation of chromosomes during cell division. The cells which have cilia or flagella contain centriole near cell membranes. These centrioles are called **basal bodies**. Basal bodies are responsible for the formation of cilia and flagella.

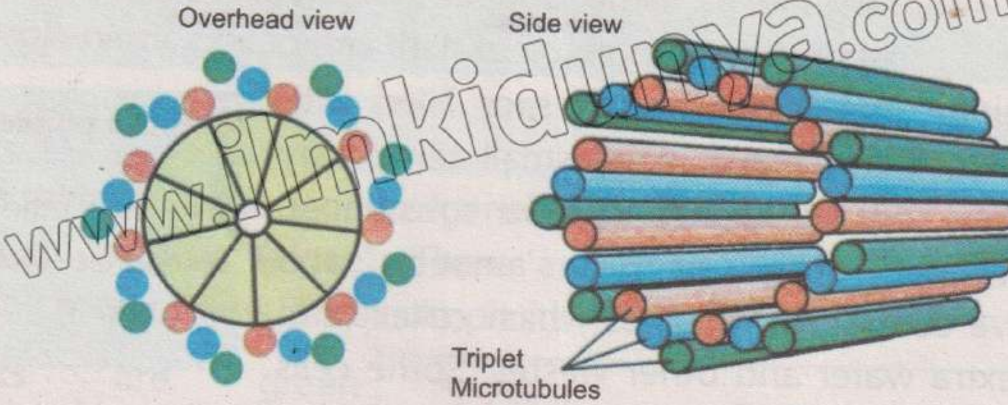


FIGURE 3.15: Structure of Centriole

Cilia and Flagella

Some cells have thin, tail-like projections called cilia (singular *cilium*) and flagella (singular *flagellum*). Cilia are short in length and are usually numerous in number; while flagella are longer but less in number. Eukaryotic cilia and flagella consist of nine pairs of microtubules which surround a single central pair of microtubules. Cilia and flagella are connected to the basal body. Prokaryotic cells also have flagella but their structure is completely different. Prokaryotic flagella are made of a protein called flagellin. The function of cilia and flagella is movement.

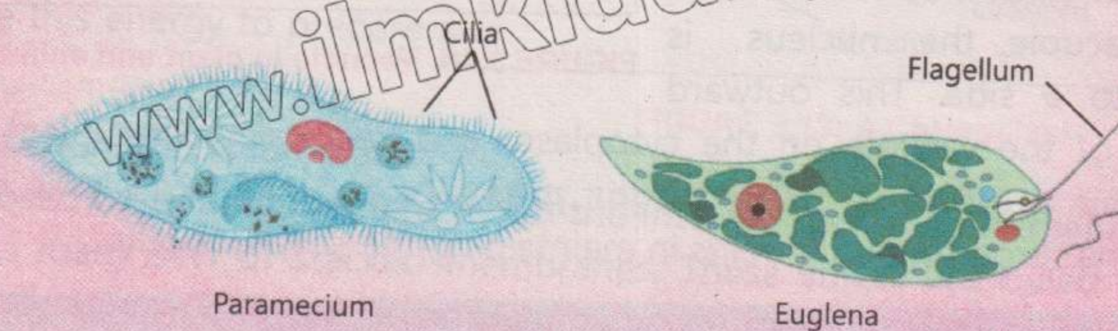


Table : Brief Comparison between Plant and Animal Cells

Component		Description	Where found	Function
Animal and Plant Cells	Cytoplasm	Jelly-like, with organelles in it	Between plasma membrane and nuclear envelope	Provides the site to cell organelles, site of metabolic reactions
	Cell membrane	A partially permeable membrane that forms a boundary around the cytoplasm	Around cytoplasm	Prevents cell contents; controls what substances enter and leave the cell
	Nucleus	A spherical or oval organelle containing DNA	In the centre in animal cells, on a side in plant cells	Controls cell division; controls cell activities

	Component	Description	Where found	Function
Plant Cells Only	Cell wall	A tough, non-living outer layer made of cellulose	Around the outside of plant cells	Prevents mechanical support; allows water and salts to pass
Plant Cells Only	Large Vacuole	A fluid-filled space surrounded by a membrane	Inside the cytoplasm of plant cells	Contains salts and water; helps to keep plant cells turgid
Plant Cells Only	Chloroplast	An organelle containing chlorophyll	Inside the cytoplasm of some plant cells	Traps light energy for photosynthesis

3.3- Structural Advantages of Plant and Animal Cells

We have studied plant and animal cells. They have distinct structural differences that reflect their specialized functions and adaptations. Here are some structural advantages of both plant and animal cells.

Advantages of Plant Cell Structures

- Plant cells have a rigid cell wall made of cellulose. It provides structural support and protection.
- They contain chloroplasts, which are responsible for photosynthesis. Chloroplasts convert light energy into chemical energy, allowing plants to produce food.
- The large central vacuole stores water, nutrients, and waste products. It provides turgor pressure that maintains cell shape.
- Plant cells are interconnected by plasmodesmata, channels that allow direct communication and transport of substances between cells.

Advantages of Animal Cell Structures

- Animal cells have centrioles which make spindle fibres. This ensures the accurate distribution of chromosomes during cell division.
- They contain lysosomes, filled with enzymes that break down waste materials. Lysosomes contribute to cellular cleanup and recycling.
- Some animal cells have structures called flagella and cilia, which are involved in movement. For example, sperm cells have a flagellum that propels them toward the egg for fertilization.

- They lack a rigid cell wall, allowing them to change shape easily. This flexibility is crucial for cell movements, such as white blood cells moving to sites of infection or injury.

3.4- CELL SPECIALIZATION

In multicellular organisms, there are different types of cells. Each type has a special structure and performs special function. When cells are formed by cell division, they are all similar. After their formation, cells undergo the process of specialization or differentiation. During this process, they get special sizes, structures, and metabolic features. As a result, they become specialized. Here we will discuss some specialized cells of plants and animals.

Mesophyll Cells: These are green cells present in leaves. They are specialized for photosynthesis. They contain large number of chloroplasts, which contain the green pigment chlorophyll necessary for capturing light energy. Their shape and arrangement in leaves is suitable for maximum absorption of light.

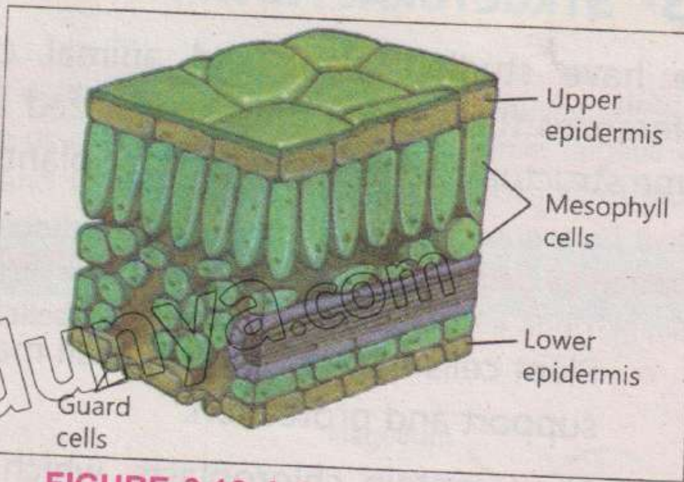


FIGURE 3.16: Internal structure of leaf showing mesophyll cells

Epidermal Cells: They are flat and tightly packed cells that make the outer layer (epidermis) of plant organs. Epidermis protects the internal tissues. Modified cells of epidermis also perform other functions. For example, the epidermis of root contains root hair cells. These cells make extensions called root hairs. Root hairs increase surface area to absorb water and minerals from soil. The lower epidermis of leaves contains guard cells which regulate the opening and closing of stomata.

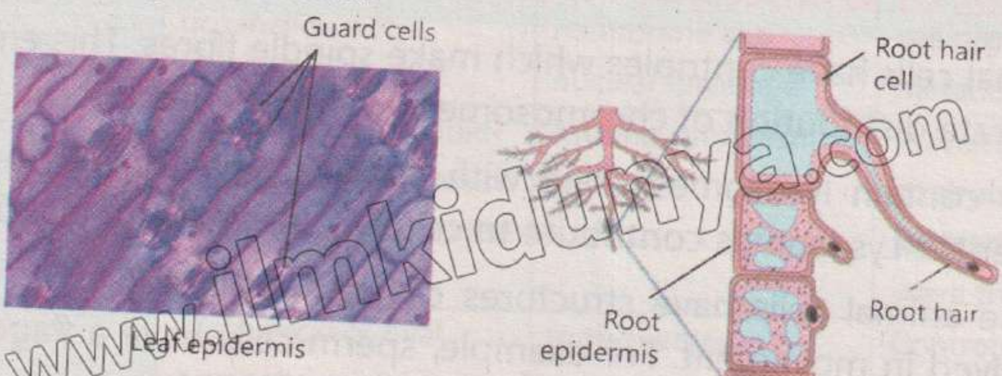


FIGURE 3.17: Epidermis of leaf and root

Muscle Cells: Muscle cells are specialized animal cells that can contract. They are elongated cells filled with actin and other contractile proteins. Skeletal muscle cells are long, striated. They are attached to bones. They are voluntary in action and their contractions move the skeleton for body movements and locomotion. Cardiac muscle cells are branched and striated. They are found in the heart walls. They are involuntary in action and their contractions result in the pumping action of heart. Smooth muscle cells are spindle shaped and non-striated. They are involuntary in action and present in the walls of many internal organs. For example, smooth muscles in the alimentary canal contract to move food forward, while those in blood vessels regulate blood flow.

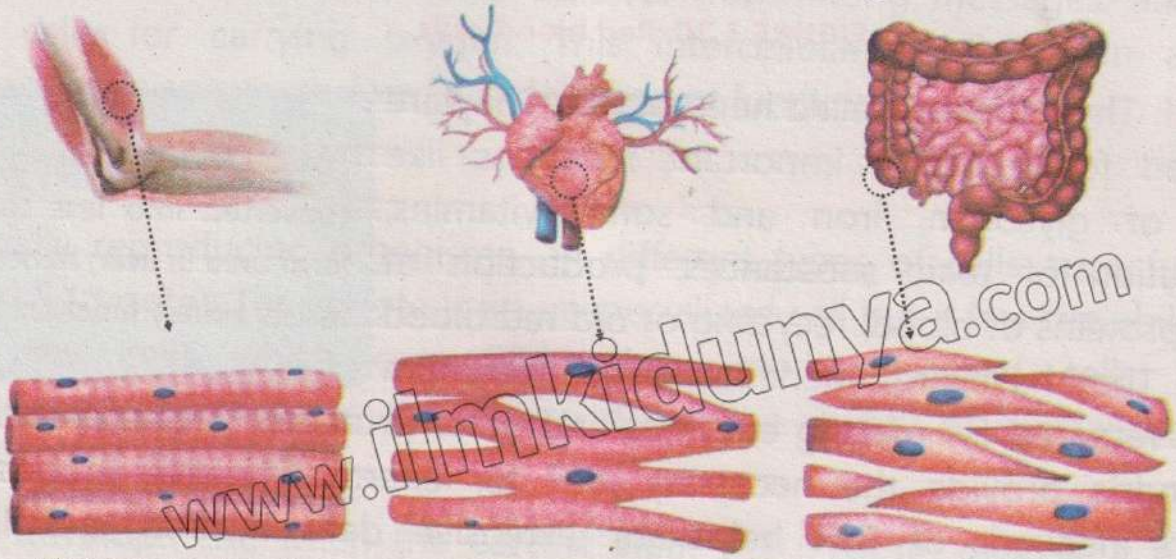


FIGURE 3.18: Muscle cells

Neurons: These are the specialized cells of the nervous system. They are responsible for transmitting messages (nerve impulses) throughout the body. To perform this function, they have a unique structure. A neuron consists of a cell body and two types of cytoplasmic extensions. Dendrites, the shorter extensions, receive nerve impulses and transmit them to the cell body. Axons, the longer extensions, carry nerve impulses away from the cell body.

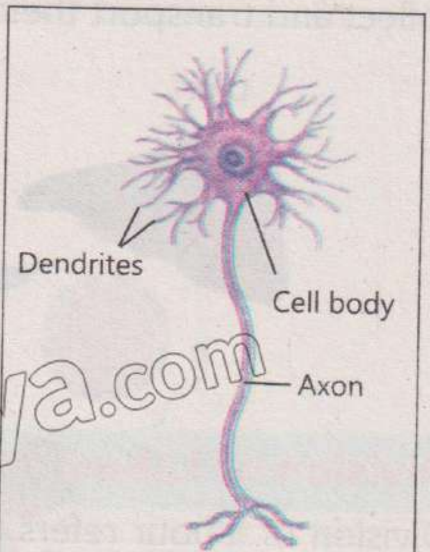


FIGURE 3.19: Neuron

Red Blood Cell (Erythrocyte): These blood cells are specialized to carry oxygen from the lungs to the body's tissues. They are biconcave disk-shaped cells. This shape provides more surface area to absorb and release oxygen. They are filled with haemoglobin that actually carries oxygen. In mammals, the mature red blood cells do not contain nucleus, mitochondria, and endoplasmic reticulum etc. It helps to accommodate more haemoglobin.

FIGURE 3.20: Red blood cells

Liver Cell: They are also called hepatocytes. They are specialized for a lot of important functions like storage of glycogen, iron and some vitamins; detoxification of toxic substances; production of clotting proteins of blood, recycling of old red blood cells etc. They have prominent nuclei for maximum activities required for making enzymes and other proteins. Large number of mitochondria provide the necessary ATP for energy-intensive processes. Expansive network of SER helps for extensive detoxification and lipid synthesis. There are large number of peroxisomes which contain enzymes to neutralize toxic substances. Small ducts are present between liver cells which collect and transport their secretion (bile) to the bile ducts.

> Toxic ammonia is converted into less toxic form urea in liver; hence it assists kidney function.

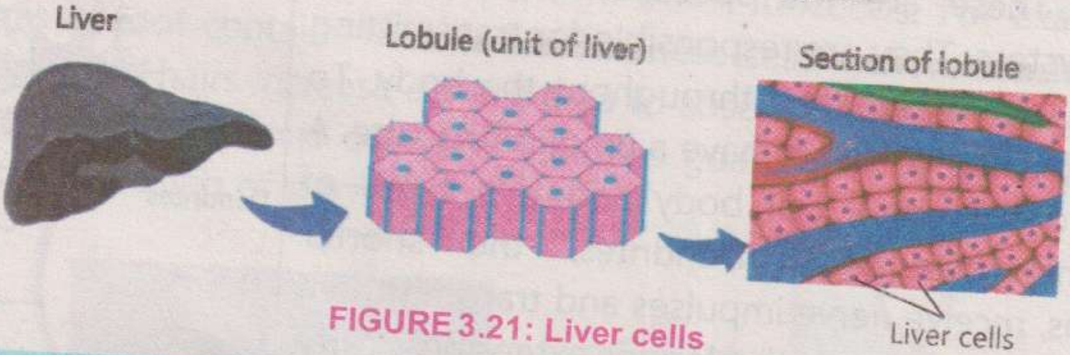


FIGURE 3.21: Liver cells

Division of Labour within and across Cells

Division of labour refers to the specialization of different parts of a system to perform specific tasks more efficiently. It is a fundamental principle that enhances efficiency and functionality in biological systems (both within and across cells).

Within Cells: Within a cell, this concept is exemplified by the various organelles that each carry out distinct functions necessary for the cell's survival. For instance, mitochondria generate energy, endoplasmic reticulum synthesizes proteins and lipids, and lysosomes break down waste materials. In this way, the function of each organelle contributes to the cell's overall survival, growth, and functioning.

Across Cells: In multicellular organisms, the division of labour extends across cells. Each type of cell performs a specific role and contributes to the overall functions of the organism. For example, muscle cells are specialized for contraction and movement, nerve cells for transmitting messages, and red blood cells for carrying oxygen. This intercellular specialization allows complex organisms to perform a wide range of functions.

3.5- Stem Cells

In sexually reproducing organisms, all different types of cells arise from a single cell (zygote). The zygote is an unspecialized cell but it has the ability to make new cells which can differentiate into specialized cells. Such unspecialized cell that has the ability to make a variety of specialized cell types is called **stem cell**.

During development, when the earliest stem cell (zygote) divides, it makes different cell lines. The cells of each line differentiate into specific type like skin cells, muscle cells, nerve cells, blood cells etc.

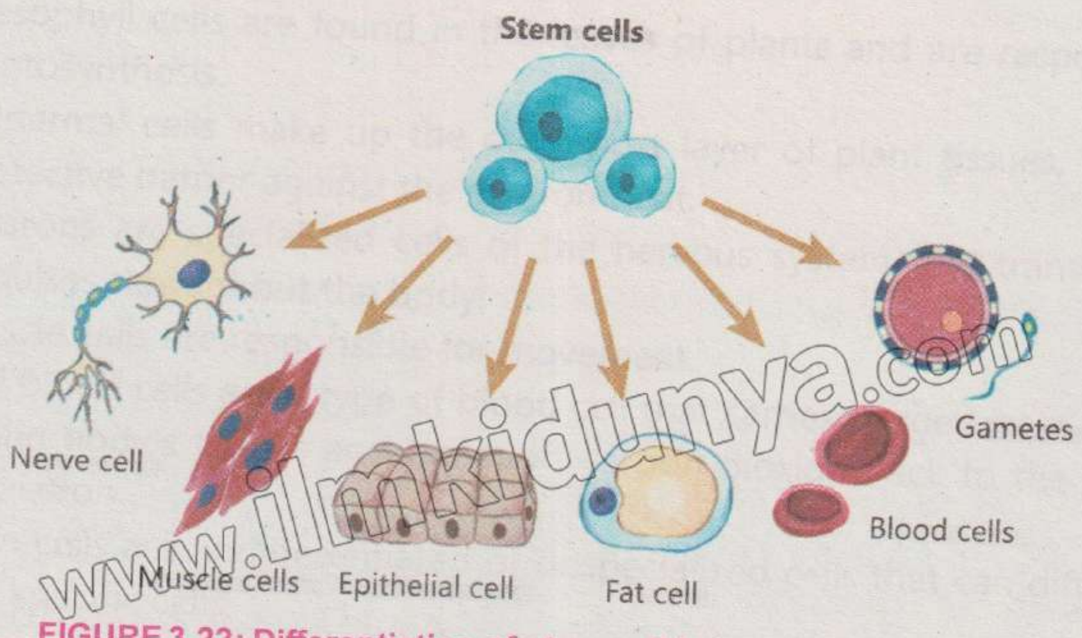


FIGURE 3.22: Differentiation of stem cell into specialized cells

Stem cells also remain in different parts of the body throughout life. These stem cells can divide and differentiate into specific cells as the body needs them. They can also regenerate damaged tissue under the right conditions. For example, stem cells present in skin help in wound healing. Stem cells present in liver also help it to repair after damage. Stem cells present in the bone marrow differentiate to make different types of blood cells and immune cells.

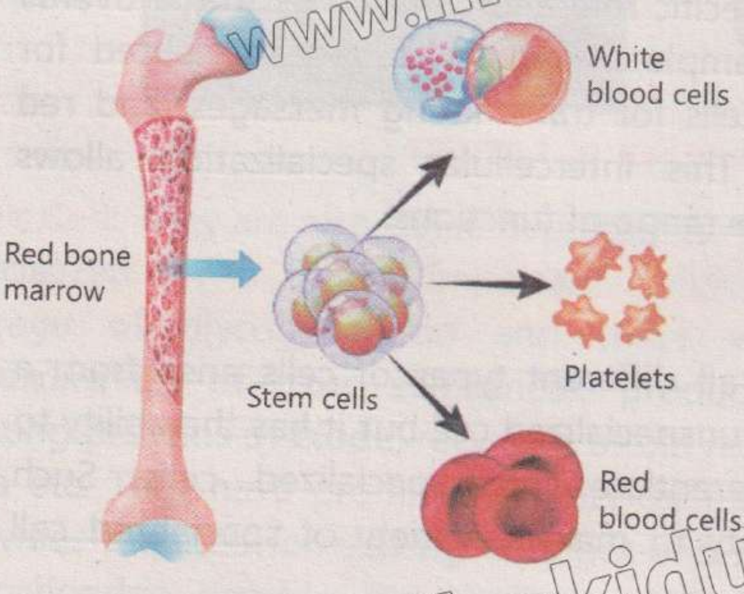


FIGURE 3.23: Stem cell of blood cells

In some parts of the body, such as the gut and bone marrow, adult stem cells regularly divide to produce new tissues for maintenance and repair.

KEY POINTS

- The cell is the fundamental building block of life.
- The primary wall of the cell wall is made up of cellulose and hemicellulose.
- The secondary cell wall is made of lignin.
- The cell membrane is made of a lipid bilayer with embedded proteins.
- Cytoskeleton is a network of microfilaments, microtubules and intermediate filaments.
- Ribosomes are made of ribosomal RNA (rRNA) and proteins.
- The Golgi apparatus is a set of many flattened sacs (cisternae) stacked over each other.
- Lysosomes have strong digestive enzymes which are responsible for breaking down various biomolecules into simpler compounds that can be used by the cell.
- Mitochondria are the "powerhouses" of the cell because they produce energy by cellular respiration.
- Chloroplasts are responsible for photosynthesis.
- Centriole is formed of 9 groups of microtubule triplets (made up of tubulin protein).
- Nucleus is spherical or oval in shape and is surrounded by a double membrane called the nuclear envelope.
- Chromosomes are composed of Deoxyribonucleic acid (DNA) and proteins.
- Mesophyll cells are found in the leaves of plants and are responsible for photosynthesis.
- Epidermal cells make up the outermost layer of plant tissues, forming a protective barrier against the environment.
- Neurons are specialized cells of the nervous system that transmit nerve impulses throughout the body.
- Muscle cells are responsible for movement.
- Red blood cells are a type of blood cell that carries oxygen from the lungs to the body's tissues and transport carbon dioxide back to the lungs for exhalation.
- Stem cells are undifferentiated or unspecialized cells that can differentiate into specific cells.

EXERCISE

A. Select the correct answers for the following questions.

1. The process of cellular respiration occurs in:
   a) Nucleus
   b) Mitochondria
   c) Ribosomes
   d) Golgi apparatus
2. The smooth endoplasmic reticulum (SER) is primarily involved in the synthesis of:
   a) Proteins
   b) Lipids
   c) Carbohydrates
   d) Nucleic acids
3. Ribosomes are composed of:
   a) RNA and protein
   b) DNA and protein
   c) Carbohydrates and lipids
   d) RNA and carbohydrates
4. What is the primary function of ribosomes?
   a).Energy production
   b) Protein synthesis
   c) Lipid synthesis
   d) DNA synthesis
5. Which cell organelle is involved in packaging and modifying proteins?
   a) Nucleus
   b) Mitochondria
   c) Golgi apparatus
   d) Endoplasmic reticulum
6. Which cell organelle is responsible for breaking down waste materials?
   a) Golgi apparatus
   b) Nucleus
   c) Mitochondria
   d) Lysosome
7. Which of the following cell structures is involved in maintaining cell shape?
   a) Cytoskeleton
   b) Centrioles
   c) Nucleus
   d) Lysosome
8. Which specialized region of the nucleus is responsible for ribosome assembly?
   a) Nucleoplasm
   b) Nucleolus
   c) Chromatin
   d) Chromatin
9. What is the main function of the nuclear pores?
   a) Regulation of cell division
   c) Protein synthesis
   b) Control of pH of the cell
   d) Control of transport of molecules

10. Which of the following cellular structures is found in animal cells and helps in cell division?

a) Cell membrane
b) Centriole
c) Plasmodesma
d) Vacuole

11. Which sub-cellular organelle plays a crucial role in energy production within the cell?

a) Endoplasmic reticulum
b) Golgi apparatus
c) Mitochondria
d) Lysosomes

12. In a multicellular plant, which cell type is responsible for the production of glucose?

a) Xylem
b) Phloem
c) Epidermal
d) Mesophyll

13. Which organelle can double its number by itself?

a) Ribosomes
b) Lysosomes
c) Mitochondria
d) Golgi apparatus

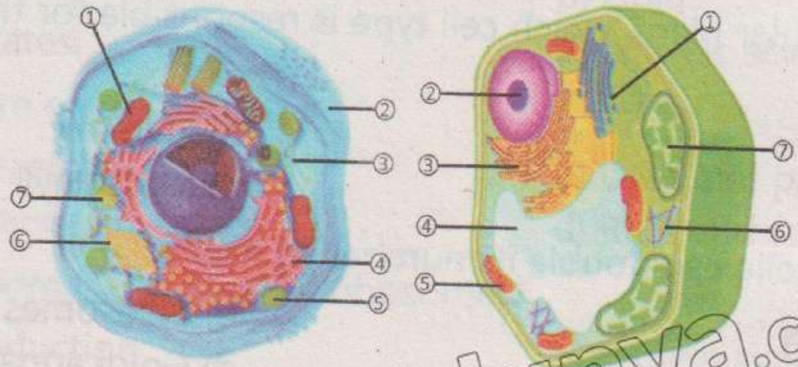
14. Which of these are present on the surface of rough endoplasmic reticulum?

a) Ribosomes
b) Lysosomes
c) Mitochondria
d) Vacuoles

B. Write short answers.

1. What are the main functions of cell membrane?
2. What key role does the Golgi apparatus play in eukaryotic cells?
3. How do lysosomes contribute to the cell's functioning?
4. Which organelle detoxifies harmful substances and breaks down lipids?
5. What is the smooth endoplasmic reticulum responsible for?
6. How do the vacuoles in plant cells differ from vacuoles in animal cells?
7. What could happen if lysosomal enzymes stop working properly?
8. Why are the cristae important for cellular respiration?
9. How are chromatin and chromosomes related?
10. Which type of cell is responsible for sending nerve signals?

11. What do mesophyll cells do in plant leaves?
12. How would you define a stem cell?
13. Name the chemical compounds that make up:
    a. Cell membrane
    b. Fungal cell wall
    c. Plant cell wall
    d. Bacterial cell wall
    e. Ribosomes
    f. Chromosomes
14. Label the parts of these cell diagrams?



C. Write answers in detail.

1. Explain the fluid mosaic model of the cell membrane.
2. Describe the structure and functions of the cell wall.
3. Discuss the components of the nucleus.
4. Describe the structure and function of lysosome and endoplasmic reticulum.
5. Describe the formation and function of the Golgi complex.
6. Describe the structure and functions of the chloroplast.
7. How does turgor pressure develop in a plant cell?
8. Write any four differences between a plant cell and an animal cell.
9. Describe the concept of division of labour and how it applies in multicellular organisms. Give at least three examples.
10. Write a note on cell specialization.

D. Inquisitive questions.

1. What impact might mitochondrial dysfunction or absence have on other organelles' ability to operate in a cell?
2. What may happen if the coordination between the ribosomes and the nucleus were to fail, and why is it so important?