ENTRANCE TEST MCQs (UHS)

1. HIV is classified as:
   A. Bacteriophage B. Retrovirus C. Oncovirus D. Icosahedrel virus
2. All viruses can reproduce within living organisms only, so they are known as:
   A. Ectoparasites B. Obligate intracellular parasites
   C. Endoparasites D. Facultative intracellular parasites
3. The viruses can reproduce:
   A. Without invading any cell B. By mitosis C. In bacterial cell D. By meiosis
4. The life cycle in which phage kills the bacteria is known as:
   A. Transduction B. Lytic cycle C. Temperate phage cycle D. Lysogenic phage cy
5. In viruses, a combined structure formed by core (Nucleic ACID. and capsid is:
   A. Nucleocapsid B. Envelope C. Prion D. Capsomeres
6. Lysogenic viruses are also known as:
   A. Enveloped phage B. Prophase C. Virulent phage D. Bacteriophage
7. Capsid, the protective coat of a virus is made up of _____ subunits known as capsomeres:
   A. Lipid B. RNA C. Protein D. DNA
8. Among followings, _____ enzyme is naturally found in human immunodeficiency virus (HIV):
   A. DNA polymerase B. Reverse transcriptase C. RNA polymerase D. Ligase
9. Capsid, the protective coat of a virus is made up of _____ subunits known as capsomeres:
   A. Lipid B. RNA C. Protein D. DNA
10. Among followings, _____ enzyme is naturally found in human immunodeficiency virus (HIV):
    A. DNA polymerase B. Reverse transcriptase C. RNA polymerase D. Ligase
11. Rod-shaped bacteria are known as _____:
    A. Spirilla B. Spirochete C. Bacilli D. Cocci
12. During unfavorable conditions certain bacteria produce:
    A. Ribosomes B. Mitochondria B. Plasmids D. spores
13. Many bacteria are motile due to presence of:
    A. Flagella B. Cilia C. Pili D. Microtubules
14. _____ is an invagination of cell membrane which helps in cell division:
    A. Fimbriae B. Mesosome C. Nucleoid D. Endospore
15. Chemical used for destroying agricultural competitors are known as:
    A. Antibiotics B. Disinfectants C. Pesticides D. Chemotherapeutic agents
16. DNA molecule in prokaryotes is:
    A. Single, circular, double stranded molecule, not bounded by membrane
    B. Double, circular molecule
    C. Linear, double stranded molecule
    D. Single, circular, double stranded molecule membrane bound
17. Nucleoid is a structure NOT found in:
    A. Campylobacter B. Spirochete C. Cyanobacteria D. Goblet cells
18. Students were asked to give a guess about a unicellular organism with darkly stained nucleus. Whic one of the following can be straight away excluded from the list?
    A. Paramecium B. Plasmodium C. Amoeba D. Lactobacillus
19. Binary fission is a characteristic cell division NOT found in:
    A. Pseudomonas B. Euglena C. Campylobacter D. E. coli
20. In which one of the following shapes, gut living symbiont *Escherichia* coli is found?
    A. Round B. Spiral C. Oval D. Rod

ANSWERS KEY

1. B	2. B	3. C	4. B	5. A	6. B	7. C	8. B	9. C	10. B	11. C	
13. A	14. B	15. C	16. A	17. D	18. D	19. B	20. D				

Chapter 03 CELLS AND SUBCELLULAR ORGANELLES

Student Learning Outcomes (SLOs)

After studying this chapter, the students will be able to:

- Describe that cells are the basic unit of life with respect to seven properties of life (movement, respiration, homeostasis, growth, reproduction, excretion, nutrition).
- State cell theory (including how to validate it and exceptions to it).
- Compare and contrast the workings of a light microscope and electron microscope with focus on resolution and magnification and live vs dead samples.
- Identify the ultrastructure of animal and plant cells.
- Describe the structure and functions of cell wall, cell membrane and subcellular organelles (endoplasmic reticulum, ribosomes Golgi apparatus, vesicles, lysosomes, peroxisome, vacuoles, mitochondria, plastids, centrioles, nucleus).
- Differentiate between prokaryotic and eukaryotic cells with diagrams.
- Explain the structure of the cell membrane and the techniques that can be used to study it.
- Define cell signaling.
- Discuss the pathway of a signal from outside the cell to the inside. (protein signal and steroid signal).
- Explain the 4 membrane transport mechanisms with diagrams (simple diffusion, facilitated diffusion, osmosis, active transport).
- Describe endocytosis and exocytosis with diagrams.
- Compare and contrast simple and facilitated diffusion.
- Define stem cells and advantages of using stem cells
- Categorize different types of stem cells.
- Evaluate the advantages and disadvantages of using induced Pluripotent Stem Cells.

- In this chapter **"Cell and Subcellular Organelles,"** we will do a detailed study of cells, the fundamental units that compose all living things.
- Building on our previous knowledge from **Grade IX**, we will explore the cell theory and examine the structures of both animal and plant cells.
- We'll also discover the vital processes of cell signaling, and the revolutionary potential of stem cells.
- Additionally, we will investigate the mechanisms of membrane transport that are crucial for cellular function.

CELLS - THE BASIC UNIT OF LIFE

- **Cells:** The basic unit of life, making up every **living organism.**
- **Unicellular Organisms:** In unicellular organisms like **amoebas and bacteria,** a single cell carries out all the functions necessary for life.
- **Multicellular Organisms:** The organisms which are composed of many cells such as plants and animals, are composed of numerous **specialized cells** that work together to sustain life.

➢ **Basic Properties of Life:**

- All living organisms show the seven **basic properties** of life.
- These properties actually define living organisms. Cells perform all the fundamental activities that characterize living organisms.

Check Understanding!
1. Which of these is a sign that something is alive?
A. It shines in the dark.
B. It moves, uses energy, and can grow.
C. It is made of metal.
D. It does not change at all.

(i) Movement: Cells can move.
- Sperm cells move with **their flagella.**
- White blood cells travel through the bloodstream to fight infections.
- Inside cells, organelles move to carry out vital functions.

(ii) Nutrition: Cells obtain nutrients from their environment to produce energy, **build cellular structures,** and drive biochemical **reactions.**

(iii) Respiration: Cells generate energy **through respiration.** This process breaks glucose to **release** ATP, the energy currency that powers cellular activities.

(iv) Excretion: Cells remove waste products through diffusion and active transport, preventing toxic buildup.

(v) Homeostasis: Cells maintain a stable internal environment by **regulating** the **movement** of substances across their membranes.

(vi) Growth: Cells grow by taking in nutrients and converting them into **cellular components.**

(vii) Reproduction: Cells reproduce through mitosis and meiosis.
- **Mitosis produces** identical daughter cells for growth and repair, **while** meiosis creates gametes for **sexual reproduction.**

CELL THEORY

➢ **Historical Background of Cell Theory:**

- At the beginning of **17th century,** many scientists began the use of microscopes to study very small objects. A few of them are discussed to here.

(i) Robert Hooke:
- In 1665, English scientist Robert Hooke examined a **thin slice of cork** of oak tree under microscope.
- He observed that the cork was made of **"many little boxes".**
- **Hooke** also examined the pieces of stem and root of oak tree under microscope.
- He found that these were also made of similar **little boxes.**
- **Cellulate:** He concluded that the parts of plants were made of compartments. Hooke named these **compartments as "cellulae".**

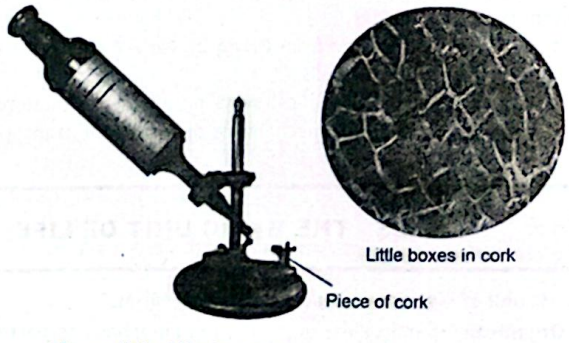


Figure : Robert Hooke's microscopeand observation

(ii) Anton Van Leeuwenhoek:
- In 1673, a Dutch scientist Anton van Leeuwenhoek made a better microscope and **observed** living cells in pond water. He called these cells as **animalcules.**

(iii) Jean Baptist de-Lamarck:
- In 1809, the French biologist Jean Baptist de-Lamarck also observed cells when he examined the parts of animals and plants under microscope.

(iv) Robert Brown:
- Later on, in 1831 the British botanist Robert Brown discovered nucleus in the cell.

(v) Matthias Schleiden:
- After these studies, biologists began to organize information about cells.
- In 1838, the German botanist Matthias Schleiden observed many parts of plants under microscope. He concluded that all plants were composed of cells.

(vi) Theodor Schwann:
- The German zoologist Theodor Schwann concluded the same for animals as was discussed by Schleiden.

(vii) Rudolf Virchow:
- In 1885, the German physician. Rudolf Virchow (1821-1902) observed that all cells come from other cells.

Check Understanding!
2. How did Rudolf Virchow help validate the cell theory?

(viii) Louis Pasteur:
- In 1862, Louis Pasteur provided the experimental **proof** of vichow idea.
- All the above observations were combined to form a basic theory **about cells.** It is called **cell theory.**

➢ **Essential Points of Cell Theory:**

i. All living organisms are composed of one or more cells.
ii. Cells are the basic units of structure and function in an organism.
iii. Cells come only from the division of pre-existing cells.

➲ **Validation of Cell Theory:**

Cell theory can be validated through several **observations and experiments.**

(I) By Using Microscopes:
- By using light microscopes and electron microscopes, scientists visualize cell structures and find tangible (Physical/Real) evidence that cells are indeed the structural units of all living organisms.

(II) By Using Techniques:
- Through techniques like **live-cell imaging** and **genetic studies,** scientists can track how cells replicate and give rise to new cells.
- These techniques validate the principle that all cells originate from **pre-existing cells.**

(iii) By Using DNA Sequences:
- Techniques like DNA sequencing reveal that cells share common genetic material and metabolic pathways, reinforcing the notion that the cell is the fundamental unit of life.

(iv) By Using Experiments:
- Such as **cell culture** studies and tissue engineering, validate cell theory by demonstrating cellular growth, differentiation, and **reproduction.**

➲ **Exceptions to Cell Theory:**

While cell theory is widely **accepted,** there are notable exceptions (Excluded).

(i) Viruses + Viroid + Prions:
- Viruses challenge cell theory because they are not made of cells and **cannot carry** out life processes independently. They require a **host** cell to replicate and are considered by many scientists to be at the border of living and non-living entities.
- Similarly, **prions** and viroids show properties of living organism but are not composed of cells. They are made of only DNA, RNA or proteins.

(ii) Eukaryotic Organelles:
- Mitochondria and chloroplasts have their own DNA and can replicate independently of the cell's nucleus. This suggests they may have originated from **free-living prokaryotic cells.**

(iii) Fung & Algae:

- Some **organisms**, such as certain **fungi and algae**, have structures where multiple nuclei coexist within a shared cytoplasmic mass. These structures **blur the boundaries** of individual cells as defined by traditional cell theory.

(iv) Muscle Cells (Myocytes):

- In vertebrates muscle cells can fuse to form **multinucleated fibres**, challenging the concept of a single cell as the basic unit in complex tissues.

MICROSCOPY

- **Microscopy:** The technique of using microscopes to observe and study objects that are too small to be seen with the naked eye is called **microscopy.**
- **Use of Microscope:** The discovery of cells and then the further studies of the internal structure of cells were dependent upon the **use of microscope.**
- **Working Principle of Microscope:** Microscopes use lenses and light or electron beams to magnify and illuminate specimens.

Check Understanding!

3. Which of the following is a major limitation of light microscopes compared to electron microscopes?

A. They are more expensive
B. They cannot be used in labs
C. They have lower magnification and resolution
D. They require special training to operate

(1) Light Microscopy (LM):

- In light microscope, light is used to make the image of **object.**
- Light passes through object and then through two **glass lenses.**
- One lens produces an **enlarged** image of the object and the second lens magnifies the image more.
- **Image Formation:** After passing through object and lenses, the light forms enlarged clear image of object in viewer's eye.

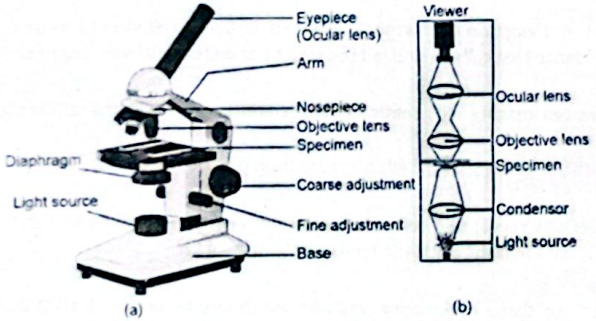


Figure: (a) Major parts of light microscope; (b) Working Principle of Light Microscope

Magnification and Resolution

- These are two key characteristics of **microscopes.**
- **Magnification:** The microscope's ability to enlarge the image of an **object.**
- Different lenses within a microscope offer varying levels of magnification. It is denoted by the symbol 'x', indicating how many times larger the image appears compared to the actual size.
- **Example:** A **10X** lens can enlarge a 1µm object to **10µ m.** Total magnification in a microscope is determined by multiplying the magnification of all lenses.
- **Resolution:** The ability of microscope to distinguish **between two points** that are close together on an object. The greater the resolution, the finer the detail that can be observed.
- **Human Naked Eyes:** The naked human eye has a resolution of about **0.1 mm.**
- In contrast, a light microscope can resolve details down to approximately **250 nm (nanometres).**

➢ **Magnification + Resolving Power of Light Microscope:**

- **Magnification:** The magnification of a light microscope is **1500 X.** It means it can magnify objects about **1500 times.**
- **Resolving Power of LM:** resolving power of light is **0.2 micrometre** (µm) and 1µm = 1/1000 mm. In other words, the light microscope cannot distinguish objects smaller **than 2µm.**
- **Advantages of LM:** Light microscopes are advantageous for viewing living organisms.
- **Disadvantages of LM:** As the living individual cells are generally transparent, their components are not distinguishable unless they are coloured with special stains (coloured chemicals). Staining, however, usually kills the cells.

(2) Electron Microscopy (EM):

Check Understanding!

4. Compare the functions of TEM and SEM in electron microscopy.

- In electron microscope, a beam of **electrons** passes through the object. Magnetic lenses focus the electron beam on a screen or photographic film and make much enlarged image.
- **Resolving Power:** Its resolving power is much greater than **light microscope.** It can clearly show objects as small as 0.2 nanometre (nm) and 1 nm = 1/1000,000 mm.
- **Drawback of EM:** Electron microscope **cannot** be used for viewing living material because of the methods needed to prepare the specimens.

➢ **Types of Electron Microscope:** (Biologists use two types of electron microscopes)

(i) Transmission Electron Microscope (TEM):

- It is used to view the **internal structure** of cell.
- TEM transmits a beam of electrons through a very **thin specimen.** It can magnify objects up to **250,000 times.**

(ii) Scanning Electron Microscope (SEM):

- It is used to study the **details of surfaces of cells** or any other objects. The surfaces are coated with metal.
- When electron beam hits the metal, it is reflected and makes enlarged image. SEMs can magnify objects up to **100,000 times.**

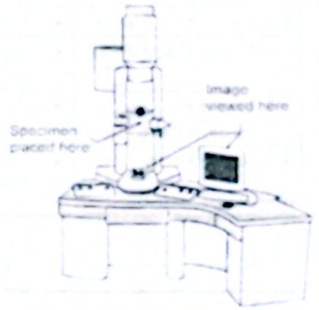


Figure: Electron microscope

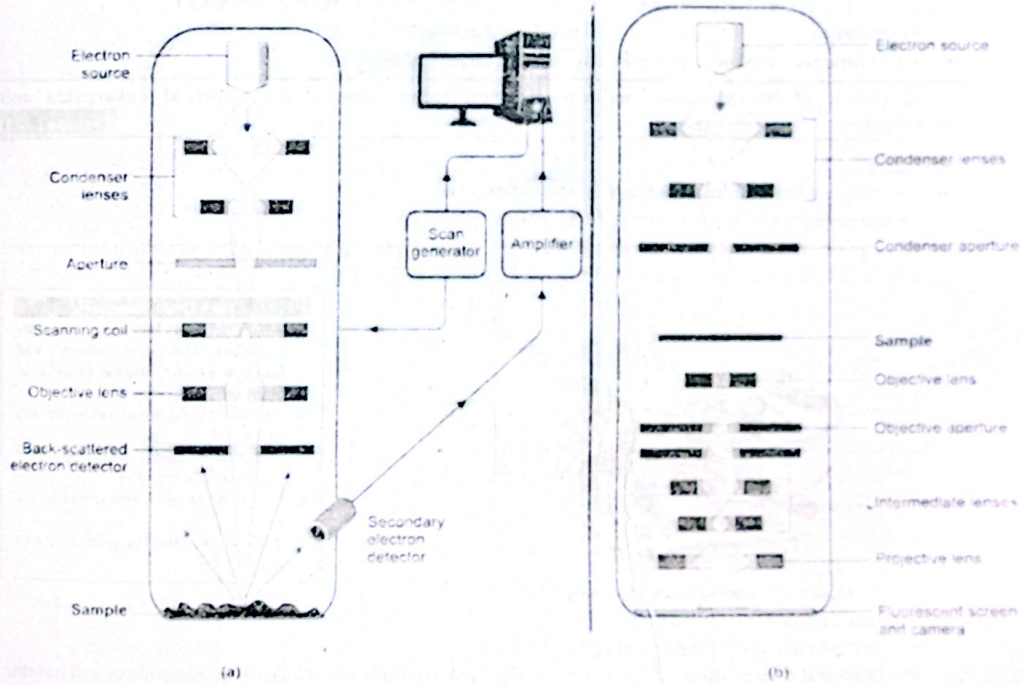


Figure: Working principle of: (a) Scanning electron microscope. (b) Transmission electron microscope

Difference Between Electron Microscope and Light Microscope

Feature/Characteristic	Light Microscope (LM)	Electron Microscope (EM)
(I) Source of Light	• Uses light (approx. 400-700 nm) as an illuminating source	• Uses electron beams (approx. 1 nm) as an illuminating source
(ii) Magnification Power	• Lower magnification (usually 500X to 1500X) than an electron microscope	• Higher magnification (direct magnification is 16000X and photographic magnification is 1000000X)
(iii) Resolution Power	• Low resolution (may be 0.2μ m)	• High resolution (may be 0.2 nm)
(iv) Types of Specimen	• Both live and dead specimens can be seen	• Only dead and the dried specimen can be seen
(v) Specimen Preparation time	• Specimen preparation takes about a few minutes or an hour	• Specimen preparation takes several days
(vi) Image Formation	• The image is seen through the ocular lens. No screen needed	• The image is received on a zinc sulphate fluorescent screen

STRUCTURE OF CELL

➢ **Basic Types of Cells:**

- You know that there are two basic types of cells: (I) Prokaryotic (ii) Eukaryotic
- All bacteria are prokaryotes. Examples of unicellular eukaryotes: Yeast and Euglena
- Examples of multicellular eukaryotes: Plants and animals
- Eukaryotic cells are more complex than the prokaryotic cells.

Q. Write details of the structure and the chemical composition of cell walls of eukaryotes and prokaryotes. (Exercise Q.1)

➲ **Cell Wall:**

- Cell wall is a more or less solid layer surrounding a cell.
- **Occurrence:** It is found in bacteria, fungi, plants, and algae.
- **Protoplast:** When a cell wall is removed using cell wall degrading enzymes, the remaining components of the cell are called a protoplast.

Figure: The composition of primary cell wall

Check Understanding!

5. Which of the following correctly describes the composition and function of the middle lamella in plant cells?
   A. It contains cellulose and gives rigidity to the cell
   B. It is rich in pectin and helps bind adjacent cells together
   C. It is made of lignin and stores waste products
   D. It forms only after the secondary wall is complete

(i) Primary Cell Wall:

- The primary wall is the actual cell wall of cell.
- **Chemical Composition:** It is composed of polysaccharides i.e. cellulose, hemicellulose and pectin.
- The cellulose microfibrils are aligned at all angles and are held together by hydrogen bonds.
- Many proteins are also present in primary walls.

(ii) Middle Lamella:

- The middle lamella is a **gelatinous layer** that separates and holds the **primary walls** of the neighbouring cells.
- It is laid first, formed from the **cell plate** during cytokinesis, and the **primary cell wall** is then expanded inside the middle lamella.
- **Chemical Composition:** It contains **magnesium** and **calcium pectates** (salts of pectic acid).

Check Understanding!

6. Compare the primary and secondary cell walls in plant cells.

(iii) Secondary Cell Wall:

- In some plant cells, after maturation, a secondary wall is made between protoplast and **primary wall.**
- **Chemical Composition:** Secondary cell walls contain **lignin, cellulose** and **hemicellulose.**
- **More Rigid:** Due to the presence of **lignin, secondary** wall is **more rigid** than the primary wall.

- **Plasmodesmata** have caused debate among scientists regarding cell theory. Some scientists suggest that the cells of higher plants are not really cells since they are not physically separated or independent from one another.

- **Plasmodesmata (Singular, Plasmodesma):** These are small channels that directly connect the cytoplasm of neighbouring **plant cells to each other.** Plasmodesmata penetrate both the primary and secondary cell walls.
- **Importance of Plasmodesmata:** They allow certain **molecules** to pass directly from one cell to another. So, they are important in cellular communication.

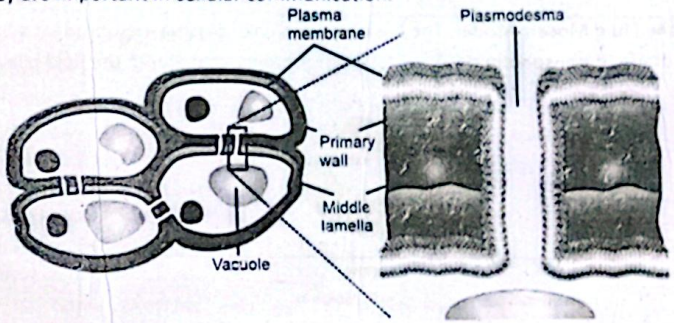


Figure: The cell walls of two neighbouring cells showing a plasmodesma

Cell Wall of Diatoms

- The group of algae called **diatoms** synthesize their cell walls from silicic acid.
- The acid is polymerized inside cells, then the wall is extruded to protect the cell.
- The synthesis of **Silica** cell walls requires less energy. That is why there are **higher growth rates in diatoms.**

- Plasmodesmata are formed during cell division when parts of the **endoplasmic** reticulum of the parent cell get trapped in the new cell wall.
- **Functions of Cell Wall + Rigidity + mechanical Support:** They **provide** rigidity to the cell for structural and mechanical support; maintain cell shape and the direction of cell growth and ultimately the architecture of the plant.

- **Prevents From Expansion:** The cell wall also prevents expansion when water enters the cell.
- **Protects Again Pathogen:** Cell walls protect against pathogens and the environment.
- **Cell Wall:** Stores carbohydrates for the plant.

- **The cell wall of algae** contains cellulose and a variety of glycoproteins.
- **The cell wall of fungi** is composed of chitin, the same carbohydrate that gives strength to the exoskeletons of insects.
- **The cell wall of prokaryotes** (bacteria and cyanobacteria) is composed of peptidoglycan, that is a single large polymer of amino acids and sugar.
- **The cell wall of archaebacteria** is composed of different polysaccharides and proteins, with no peptidoglycan.

Plasma Membrane:

All prokaryotic and eukaryotic cells have a plasma membrane that encloses their contents and serves as a **semi-porous** barrier to the outside environment.

Check Understanding!

7. Which feature of the eukaryotic plasma membrane allows selective transport of materials?

A. Presence of a cellulose layer
B. Protein channels and carrier proteins
C. DNA embedded in the membrane
D. Rigid phospholipid tails

Structure of Plasma Membrane:

- **Fluid Mosaic Model:** The fluid mosaic model is a widely accepted concept that describes the dynamic nature of plasma membrane.
- It was proposed by two American biologists S.J. Singer and Garth Nicolson in 1972.
- **According to the Fluid Mosaic Model:** The basic foundation of plasma membrane is a lipid bilayer.
- This bilayer is made of **phospholipids**. A collection of proteins float within the lipid bilayer.

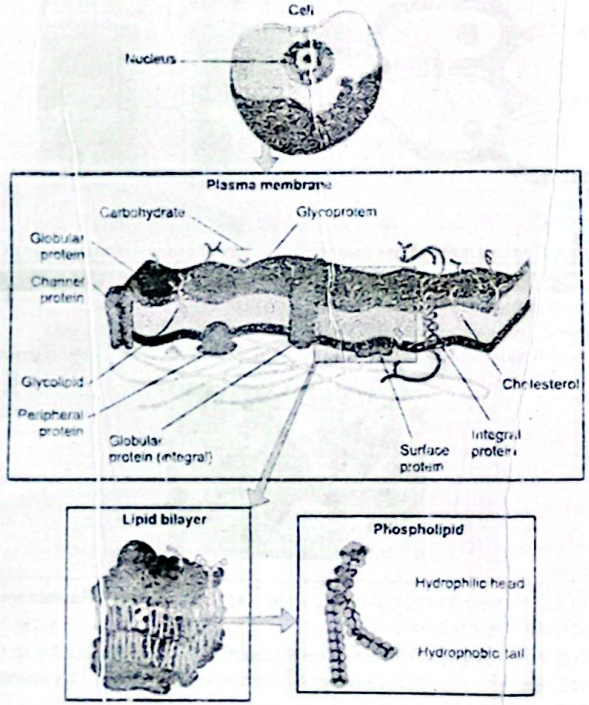


Figure: Structural components of plasma membrane

Arrangement of Phospholipids:

- The phospholipids have a phosphate group at one end of each molecule.
- Phospholipids are characteristically **hydrophilic** ("water-loving") at their **phosphate ends** and **hydrophobic** ("water-fearing") along their tail regions containing C-H chains.
- In the lipid bilayer of plasma membrane, the hydrophobic **lipid tails** are oriented inwards and the hydrophilic phosphate groups are aligned outwards, either toward the cytoplasm of the cell or the extracellular environment.

- The interior of lipid bilayer sheet is **hydrophobic.** It repels water-soluble molecules that attempt to **pass through it**.
- If a cell was fully encased in pure lipid bilayer, it would be completely impermeable to water-soluble molecules e.g., sugars, polar amino acids etc.
- That is why, in addition to **phospholipids** molecules, the membranes also contain proteins that provide passageways across the membrane.

Plasma Membrane of Eukaryotes:

- In eukaryotes, plasma membranes have cholesterol molecules, wedged into the **phospholipid** bilayer.
- They keep the fluidity of membrane at **low temperatures**. Many proteins float within the phospholipid bilayer of plasma membrane. Some other proteins simply adhere to the surfaces of the bilayer. The positioning of proteins is related to the organization of **cytoskeleton**.

Check Understanding!

8. Describe how the plasma membrane in eukaryotic cells supports selective transport.

Q. Explain the chemical composition and the functions of plasma membrane. [Exercise Q.2]

Functions of Plasma Membrane Proteins:

- **Transport:** Many proteins play role in the selective transport of certain substances across the phospholipid bilayer, either acting as channels or active transport molecules.
- **Attachment:** Some proteins help in attachment of plasma membrane to cytoskeleton and external fibres.
- **Identification Marks:** Some proteins, on the exterior surface, attach with sugars and make identification marks.
- **Receptors:** Other proteins function as receptors, which bind messenger molecules (e.g. hormones) and transmit signals to the interior of cell.
- **Catalysts:** Some proteins also exhibit enzymatic activity, catalysing various reactions related to the plasma membrane.

- The ability to distinguish among different cells is crucial to life. It allows cells in an embryo to sort themselves into tissues and organs. It also helps cells of the immune system to recognize and reject foreign cells, e.g., infectious bacteria.

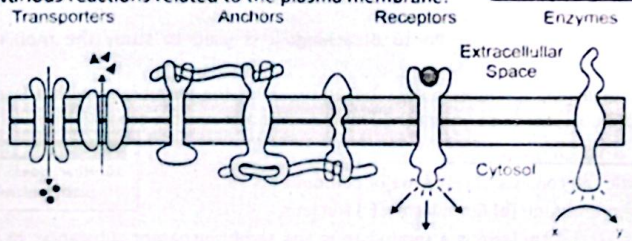


Figure: Major types of plasma membrane proteins

- The outside surface of plasma membrane has chains of sugars bonded to proteins and lipids.

Q. Identify the role of glycolipids and glycoproteins as the cell surface markers. [Exercise Q.3]

- **Glycoproteins + Glycolipid:** A protein with attached sugar is called a **glycoprotein**, whereas a lipid with attached sugar is called a glycolipid.
- The **glycoproteins and glycolipids** vary from **species to species**, from individual to individual in the same species, and even from one cell type to another in the same individual. The glycolipids and glycoproteins (collectively called glycocalyx) function as cell identification marks that are recognized by other cells.

Membrane	Percent by weight		
	Protein	Lipid	Carbohydrate
• Human red blood cell	49	43	8
• Mitochondria (outer membrane)	52	48	0
• Mitochondria (inner membrane)	76	24	0
• Bacteria	75	25	0

➢ Functions of Plasma Membrane:

- **As Semi-Porous Barriers:** Plasma membranes serve as semi-porous barriers to the outside environment. The membrane acts as a boundary, holding the cell constituents together. The plasma membrane is permeable to specific molecules, however, and allows nutrients and other essential elements to enter the cell and waste materials to leave the cell.
- **Molecules Cross Easily:** Small molecules, such as oxygen, carbon dioxide, and water, are able to pass freely across the membrane.
- **Molecules Carefully Regulated: Larger molecules,** such as amino acids and sugars, is carefully regulated.
- Eukaryotic cells also have membranes around some of their interior organelles. Like the exterior plasma membrane, these membranes also regulate the flow of materials into and out of organelles.

Check Understanding!

9. A cell is compared to a city. If the nucleus is the city hall and organelles are factories, what best represents the cytosol?

A) The roads connecting factories
B) The air filling the city
C) The land where everything is built and functions
D) The power lines supplying energy

➢ Techniques to Study the Structure of Plasma Membrane:

i. **Transmission Electron Microscopy (TEM):** It can reveal detailed structures of the lipid bilayer and associated proteins.
ii. **Scanning Electron Microscopy (SEM):** It is useful for examining the surface topology of cells and membranes.
iii. **Confocal Microscopy:** It uses laser scanning and **fluorescence** to create sharp, detailed images of the cell membrane.
iv. **Total Internal Reflection Fluorescence Microscopy:** It is used for high-resolution images of the membrane and its interactions with the cytoskeleton and other cellular components.
v. **Atomic Force Microscopy:** It provides topographical images of cell membrane at high resolution.
vi. **X-ray Crystallography:** It is used to determine the atomic structure of membrane proteins.
vii. **Lipidomics:** It involves the comprehensive analysis/study of lipids in the cell membrane using techniques like mass spectrometry.
viii. **Fluorescence Recovery after Photo Bleaching:** It is used to study the mobility and dynamics of membrane proteins and lipids.
- It involves bleaching a fluorescently labelled region of the membrane with a laser and observing the recovery of fluorescence as unbleached molecules move into the area.

Check Understanding!

10. How does TEM help study the plasma membrane?

➲ Cytoplasm and Organelles:

- A eukaryotic cell consists of three **major components** i.e.,
  (a) Plasma membrane **(b)** Cytoplasm **(c)** Nucleus
- **Cytoplasm:** The cytoplasm is a **semi-viscous** and semitransparent substance. In eukaryotic cells, it is present between the plasma membrane and **nuclear envelope.**
- In prokaryotic cells, it covers all the space beneath plasma membrane.
- **Cytosol:** Cytoplasm consists of an aqueous ground substance, known as **cytosol** which contains a variety of organelles and other inclusions. Cytosol **contains water** in which many organic (proteins, carbohydrates, lipids) and inorganic salts are completely or partially dissolved.
- **Importance of Cytoplasm:** The cytoplasm of the cell provides space for the proper functioning of the organelles and also acts as the site for various biochemical (metabolic) reactions for example **Glycolysis** (breakdown of glucose during aerobic respiration).

- **Organelles:** The cytoplasm contains discrete structures which are specific for **various cellular** functions and are called **cell organelles** the organelles are generally enclosed by membrane except few such as ribosome.
- The following paragraphs describe the structures and functions of **important organelles.**

Check Understanding!

11. Which nuclear structure controls the movement of molecules in and out of the nucleus?

A) Nucleolus B) Nuclear envelope
C) Chromatin D) Nuclear lamina

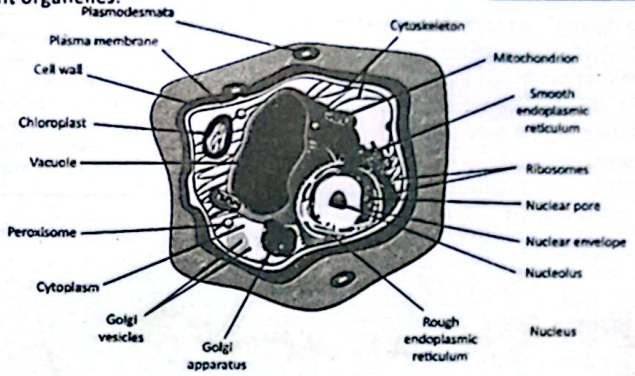


Figure: The Ultra-structure of a Plant cell

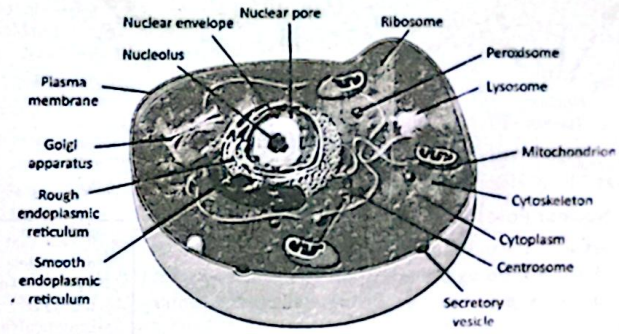


Figure : The Ultra-structure of an Animal cell

(1) Nucleus:

- A prominent nucleus is present in all **eukaryotic cells** (at centre in animal cells while pushed to side in plant cells).
- The spherical nucleus typically occupies **about 10 percent** of a eukaryotic cell's volume.
- **Functions of Nucleus:** It serves as information processing and administrative centre of the cell.
- **It performs two major functions:**
  (i) It stores the cell's **hereditary material** (DNA).
  (ii) It coordinates the cell's activities e.g., growth, protein synthesis and cell division.
- **Nucleoplasm:** The semifluid matrix found inside the nucleus is called nucleoplasm within the **nucleoplasm,** most of the nuclear material consists of chromatin that **organizes** to form chromosomes during cell division.
- The nucleus also contains one or more **nucleoli,** which synthesize **ribosomes.**

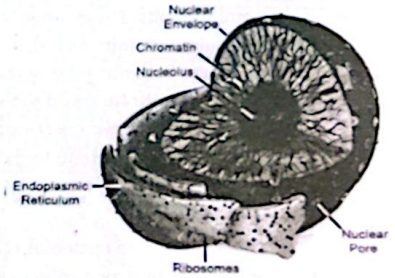


Figure: The structure of nucleus

Q. Discuss nuclear envelope and nuclear pore complex in detail. (Exercise L.Q.5)

The Nuclear Envelope and Nuclear Pores:

- The nuclear envelope is a **double-layered** membrane that encloses the contents of the nucleus during most of the cell's lifecycle.
- **Perinuclear Space:** The space between the double layers is called the perinuclear space and is connected with the rough **endoplasmic reticulum.**
- During cell division, the nuclear envelope disintegrates, but reforms in the daughter cells.
- **Nuclear Lamina:** On the inner side of nuclear envelope, there is a protein lining, called nuclear lamina It binds to chromatin to give it structural **support.**

Check Understanding!
12. What is the importance of nuclear pores in cellular function?

- Building blocks of DNA and RNA and ATPs are allowed to enter into the nucleus.
- Ribosomal subunits which are built in nucleoli are the examples of materials that are allowed to leave the nucleus and enter the cytoplasm.

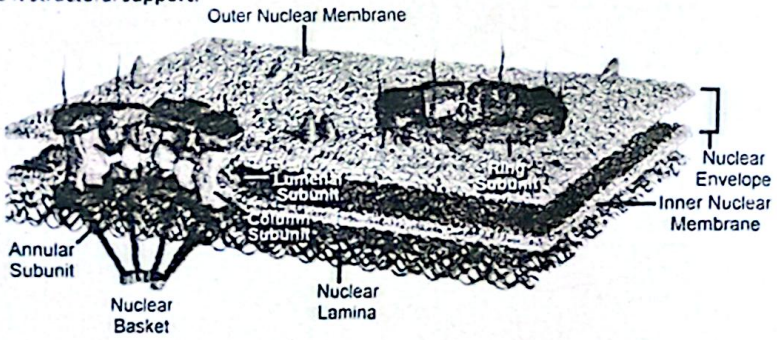


Figure: The structure of nuclear envelope and nuclear pore complex

- **Nuclear Pores:** The nuclear envelope has tiny holes known as **nuclear pores.**

Importance of Nuclear Pores:

- These pores regulate the passage of molecules between nucleus and cytoplasm. Nuclear pores are permeable to small molecules. Some larger **proteins**, e.g., histones, are also allowed to enter into nucleus.
- **Nuclear Pore Complex:** A nuclear pore is made of an elaborate structure called the nuclear pore complex. It is composed of several subunits. These are given As;
  (a) Annular Subunit: Surrounding the inside of the pore.
  (b) Column Subunit: Making the wall of the complex.
  (c) Ring Subunit: Attached to the outer side of the column subunit.
  (d) Lumenal Subunit: Anchoring the pore complex into the nuclear envelope.
- Tiny fibrils usually extend form the complex and make a **basket-like structure** on the nuclear side of the complex.

- **In cells that produce** large amounts of protein, and thus require significant numbers of ribosomes the size of the nucleolus is considerable.
- At the **onset of mitosis**, the single nucleolus present in cell disappears and after division new nucleolus is formed from the **NORs**.

Nucleolus:

- **As Dark Stain:** The nucleolus is a prominent darkly **stained** structure in the **nucleoplasm.**
- **Number:** There may be one or two nucleoli in a nucleus.
- Nucleoli manufacture the subunits that combine to form **ribosomes.**
- **Nuclear Organizer (NORs):** Nucleoli are formed at certain sites in chromosome, called Nucleolus Organizer Regions (NORs). The DNA found at NORs encodes the ribosomal RNA (rRNA).

Two Regions of Nucleolus:

- The nucleolus consists of: **(i)** Granular Region **(ii)** Fibrillar Region components, and DNA
  (i) Granular Region: The granules consist of ribosomal subunits that have already been formed.
  (ii) Fibrillar Region: The fibrils are composed of the raw materials of ribosome subunits i.e., rRNA molecules and associated proteins.

Check Understanding!
13. Which of the following correctly describes the function of the nucleolus?
A) Chromatin storage
B) DNA packaging
C) Ribosomal RNA synthesis
D) Membrane transport

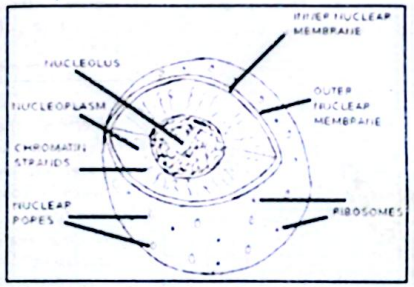


Figure: The nucleolus within a nucleus

- Inside the nucleus of every human cell, there is a **6 feet long DNA.**
- It is subdivided into 46 individual molecules (each **1.5 inches long**), one for each chromosome.

Q. Describe the structure, chemical composition and function of chromosome. (Exercise L.Q.6)

Chromatin and Chromosomes:

- **Chromatin:** Nucleus contains string-like fibres, collectively called **chromatin.** It is composed of **DNA** and proteins.
- **Nucleoplasm:** The structure of chromatin reveals that it is made of a series of **bead-like structures,** called nucleosomes. In a nucleosome, DNA strand wraps around groups of small proteins called histones.
- During interphase (when the cell is carrying out its normal functions), the chromatin is dispersed throughout the nucleus in the form of a **tangle of fibres.**
- **Chromosome:** When the cell begins to divide, all chromatin strands are compressed into specialized structures, the chromosomes.
- **Chromatid + Centromere:** A chromosome is made of arms, called chromatids, and a central point, called centromere.

Types of Chromatin
- There are two types of chromatin
(i) Euchromatin: It is the genetically active chromatin involved in transcribing RNA to produce proteins.
(ii) Heterochromatin: The other kind of chromatin is termed heterochromatin. Its DNA is genetically **inactive.**

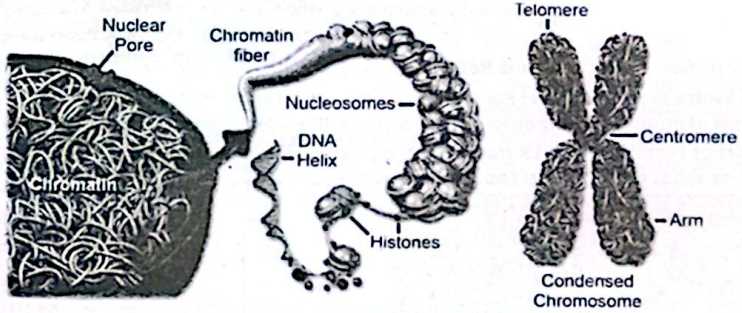


Figure: Condensation of chromatin to form a chromosome

Chromosome Numbers in Different Organisms:

- The number of chromosomes within the nuclei of an organism's cells is species-specific.
- Human diploid cells (those that are not gametes) have **46 chromosomes.**

- The chromosome number may be as low as 2, as in some **ants** and **roundworms**, or more may be than a **thousand**, as in the Indian fern *(Ophioglossum reticulatum)* which has **1,260 chromosomes**.
- It means that the number of chromosomes in a **species does not correlate** to the complexity of the organism.

(2) Endoplasmic Reticulum (ER):

- A network of **flattened sacs** and branching tubules that extends throughout the cytoplasm in plant and animal cells is called **Endoplasmic Reticulum.** These **sacs and tubules** are collectively called **cisternae** (singular cisterna).

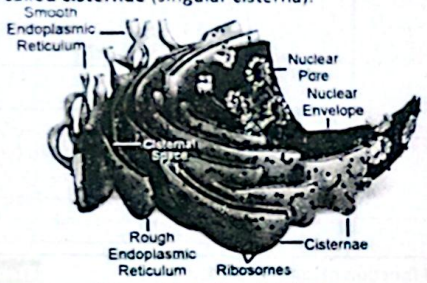


Figure: Endoplasmic reticulum

Check Understanding!

14. Explain the function and significance of the perinuclear space.

- Due to their physical membranous connection, the **lumen** of the **endoplasmic** reticulum and the space between the layers of the nuclear envelope comprise a single compartment.
- This close association enables the endoplasmic reticulum and the nucleus to share information in a very efficient manner.

- **Cisternal Space:** All cisternae are interconnected so that the ER has only **one large** and highly convoluted lumen, called **cisternal space**. It takes up more than **10 percent** of the total **volume of a cell.**
- The cisternae are also connected to the double-layered nuclear envelope. So, the ER provides a pipeline between nucleus and cytoplasm.
- The ER manufactures, processes, and transports a wide variety of biochemical compounds for use inside and outside of the cell.

Q. Describe the structure and functions of smooth and rough endoplasmic reticulum. (Exercise L.O.)

➢ Types of Endoplasmic Reticulum:

- There are two kinds of Endoplasmic reticulum:
  (i) Rough Endoplasmic reticulum
  (ii) Smooth Endoplasmic reticulum

(i) Rough Endoplasmic Reticulum:

- The surface of **rough endoplasmic reticulum (RER)** is covered with ribosomes, giving it a bumpy appearance when viewed through the microscope.

Figure: A fluorescence image of an endothelial cell showing ER (green)

➢ Importance of Rough Endoplasmic Reticulum:

- **Protein Synthesis + Processing:** Rough endoplasmic reticulum is involved mainly in the production and processing of proteins. During processing of proteins, RER adds other chemicals (e.g. sugars) to proteins.
- **Transport of Protein:** Then RER transports the processed proteins to areas of the cell where they are needed, or sends them to **Golgi apparatus** for further processing and modification.

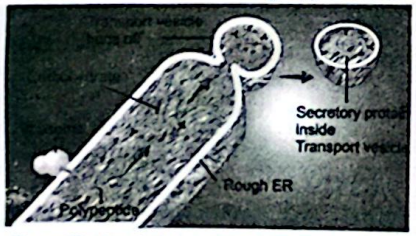


Figure: The functioning of rough endoplasmic reticulum

- Smooth endoplasmic reticulum is much more extensive in the cells which do lot of lipid and carbohydrate metabolism (brain and muscle) or detoxification (liver).

(ii) Smooth Endoplasmic Reticulum:

- The surface of smooth endoplasmic reticulum (SER) lacks ribosomes. So, it appears more even **under the** microscope. In most cells, it is much less **extensive** than the rough endoplasmic reticulum.

➢ Importance of Smooth Endoplasmic Reticulum:

- **Lipids Production:** Smooth endoplasmic reticulum is chiefly involved in the production of **lipids, building blocks** for **carbohydrate metabolism**, and the detoxification of drugs and poisons.
- **Storage + Calcium Metabolism:** Smooth endoplasmic **reticulum** also plays a role in various cellular activities by storing calcium and doing **calcium metabolism**. In muscle cells, smooth endoplasmic reticulum releases calcium to trigger muscle contractions.

Check Understanding!

15. Which statement about the sternal space (cisternal space) is FALSE?

A) It is the fluid-filled space within the ER.
B) It is continuous with the perinuclear space.
C) It is involved in protein modification and folding.
D) It is located between the inner and outer mitochondrial membranes.

Q. Explain the structure, chemical composition and function of ribosomes. (Exercise L.O.4)

(3) Ribosomes:

- All living cells **contain ribosomes** that are tiny granular structures composed of approximately **60 percent** ribosomal RNA (rRNA) and **40 percent protein**.
- **Non-Membranous:** Ribosomes are not bound by a membrane and are much smaller than other organelles.
- **In Eukaryotic Cells:** Ribosomes are mainly found attached to rough endoplasmic reticulum and some are scattered freely.
- **In prokaryotic Cells:** All ribosomes are freely scattered in cytoplasm.

➢ Functions of Ribosomes:

- **Machinery of Protein:** Ribosomes serve as the protein production machinery for the cell. They are most abundant in cells that are active in protein synthesis, such as pancreas and brain cells. A typical cell contains several thousand ribosomes but some cell types may have a **few million ribosomes.**

➢ Production of Eukaryotic Ribosomes:

- Eukaryote ribosomes are produced and assembled in the nucleolus. Ribosomal proteins enter the nucleolus and combine with rRNA strands to create the two **ribosomal subunits** (one small and one large).
- The ribosome subunits leave the nucleus through the nuclear pores. In the cytoplasm, both subunits combine for the purpose of protein synthesis. When protein synthesis is not being done, the two subunits get separated.

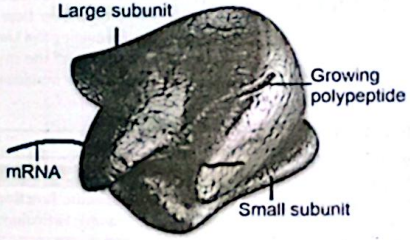


Figure: Ribosome translating the mRNA

Presence of Ribosomes in Organelles

- In addition to the most familiar cellular locations of ribosomes, they can also be found inside **mitochondria** and the **chloroplasts of plants.**
- These ribosomes notably differ in size and makeup than the ribosomes found in cytoplasm, and are more like those present in prokaryotes.

➢ Mechanism of Protein Synthesis:

- Protein synthesis requires the assistance of two other kinds of RNA molecules in addition to rRNA.
- **Messenger RNA (mRNA)** provides the instructions, which it has taken from the DNA.
- **Transfer RNA (tRNA)** brings amino acids to the ribosome. Once the chain of amino acids has been synthesized, the ribosome releases it.

Sub-units of Ribosomes:

- The subunits of a ribosome are described by their **Svedberg (S)** values, which are based upon their rate of sedimentation in a centrifuge.
- The complete ribosome in a eukaryotic cell has a Svedberg value of **80 S.**
- **Smaller Sub-Unit:** The smaller subunit has value of 40 S.
- **Larger Sub-Unit:** The larger subunit has 60S.
- Prokaryotic cells, on the other hand, contain 70S ribosomes, each of which consists of a 30 S and a 50 S subunit.

- The proteins that are synthesized by free ribosomes are for the cell's own internal use.
- While the proteins produced by the ribosomes bound to RER are transported outside of the cell.

Q. Describe the basic structure of a mitochondrion, from outside inward. (Exercise Q.2)

(4) Mitochondria:

- Mitochondria (sing., mitochondrion) are **rod-shaped** organelles that are considered the power generators of the cell.

Structure of Mitochondrion:

- A mitochondrion is bounded by two membranes. There is a narrow intermembrane space between the two membranes. Beneath the inner membrane, there is a larger internal matrix.
- **Outer Membrane:** The outer membrane is smooth and acts like a sieve, filtering out molecules that are **too big.**
- **Inner Membrane:** The inner membrane is highly convoluted and forms many infoldings called cristae which increase the surface area.

Svedberg Values

- The Svedberg values are not additive i.e. the values of the two subunits of a ribosome do not add up to the Svedberg value of the complete ribosome.
- This is because the rate of sedimentation of a molecule depends upon its size and shape, rather than simply its molecular weight.

Structure of Inner Surface of Cristae:

- **F-1 Particle:** The inner surface of the cristae has **knob-like extensions** into the matrix, known as F–1 particles. These particles are actually the enzymes called ATP-synthase. Other complexes are also found in inner mitochondrial membrane, which serve as electron carriers in electron transport chain.
- **Differences from Other Organelles:** Mitochondria are different from most other organelles.
- A mitochondrion has its own circular DNA (similar to the DNA of prokaryotes), all kinds of RNA **and 70S ribosomes.**
- A mitochondrion can replicate independently of the cell.

Hypothesis of Origin Mitochondrion

- Scientists hypothesize about the origin of mitochondria.
- According to them, millions of years ago small, **free-living prokaryotes** were engulfed, but not consumed, by larger prokaryotes.
- The two organisms developed a symbiotic relationship over time, the larger organism providing the smaller with ample nutrients and the smaller organism providing ATP molecules to the larger one.

Importance of Mitochondria:

- **Site of Cellular Respiration:** Mitochondria are the sites of cellular respiration. They generate adenosine triphosphate (ATP) from oxygen and nutrients. ATP is the chemical energy "currency" of the cell that powers the cell's metabolic activities.
- Enzymes in the matrix catalyse some of the steps of cellular respiration like **Krebs cycle.** Other proteins that function electron transport chain are found on the inner membrane.

Check Understanding!

16. What are the specific functions of smooth endoplasmic reticulum?

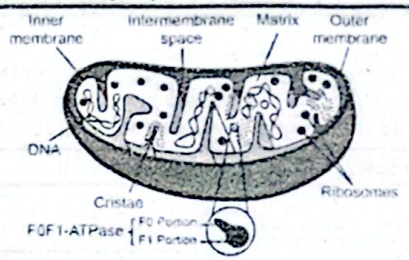


Figure: Structure of a mitochondrion

Presence of Mitochondria in Cell

- The number of mitochondria present in a cell depends upon the metabolic requirements of that cell, and may range from one to thousands.
- Mitochondria are found in nearly all eukaryotes, including plants, animals, fungi, and protists, and are large enough to be observed with a light microscope.

(5) Chloroplasts:

- **Most important Feature of Plant:** One of the most important characteristics of plants is their ability to conduct photosynthesis i.e., to make their own food by converting light energy into chemical energy. This process occurs in almost all **plant species** and is carried out in specialized organelles known as chloroplasts.
- **Location of Chloroplast:** All of the green structures in plants, including stems and unripened fruit, **contain chloroplasts,** but the majority of photosynthetic activity in most plants occurs in the leaves.
- On the average, the chloroplast density on the surface of a leaf is about one-half million per square millimetre.
- **Pigments Present in Chloroplast:** Chloroplasts contain the pigments chlorophyll "a" and chlorophyll "b", which are able to absorb the light energy needed for photosynthesis to occur.

Types of Plastids

- Cells of plants and many protists have three types of **plastids** i.e.,
  (i) Chloroplasts (ii) Chromoplasts
  (iii) leucoplasts.
- The colourless leucoplasts are involved in the storage and yellow-to-red coloured chromoplasts give colours to plant parts.

Similarities B/W Mitochondria and chloroplast

- Both organelles convert energy for the cell. Mitochondria perform aerobic respiration. They generate chemical energy in the form of ATP by metabolizing sugars, fats and other chemical fuels with the assistance of oxygen. Chloroplasts perform photosynthesis.
- They convert energy from the sun into the biosynthesis of organic nutrients using carbon dioxide and water.
- Like mitochondria, chloroplasts also contain their own DNA and are able to grow and reproduce independently of the cell.

Structure of Chloroplast:

- **Intermembrane Space:** The ellipsoid-shaped chloroplast is enclosed by two membranes and the area between the two membranes is called the intermembrane space.
- **Stroma:** A semi-fluid called stroma is present inside the inner membrane. It contains dissolved enzymes and comprises most of the chloroplast's volume. The outer membrane is much more permeable than the inner layer.
- **Thylakoid:** The inner membranes lie in close association with one another and fuse along their peripheries. In this way, two adjacent membranes form a disk-shaped compartment called thylakoid.
- **Grana:** Many thylakoids form stacks called grana (singular granum).
- **Lamellae:** The lamellae are the non-green compartments that connect two grana. Each granum may contain a few to several thylakoids, and a chloroplast may contain a hundred or more grana. Like the mitochondrion, the chloroplast is different from most other organelles because it has its own DNA and reproduces independently of the cell in which it is found.

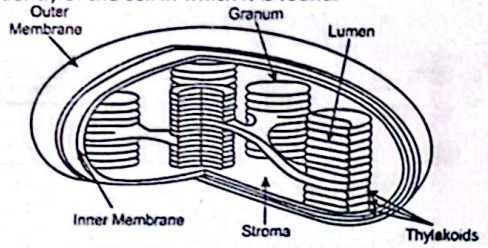


Figure: Structure of chloroplast

➢ **Absorption of Light by Chlorophyll:**

- Light is absorbed by chlorophyll molecules embedded in the thylakoid disks. When these chlorophyll molecules absorb light, they emit electrons and thus ATPs are formed. Using these ATPs, in the stroma low-energy carbon dioxide is transformed into a high-energy compound like glucose.

Q. Explain the structure, and functions of Golgi complex. [Exercise L.Q.5]

(6) Golgi Apparatus:

- **Cisternae:** Golgi apparatus consists of five to eight cup-shaped, membrane-covered sacs called cisternae that are stacked over each other.
- **Golgi apparatus** is found in the cells of plant, animal and cellular eukaryotes.
- In some unicellular flagellates, the Golgi apparatus may consist of 60 cisternae. Similarly, the number of Golgi apparatuses in a cell varies according to its function.
- Animal cells generally contain between ten and twenty Golgi stacks in their Golgi apparatus. This complex is usually located close to the nucleus.

- **Golgi apparatus** was discovered by **Camillo Golgi.**
- Camillo Golgi was investigating the nervous system by using a new staining technique (known as Golgi staining).
- He observed a structure inside cells and named it as reticular apparatus.
- He publicly announced his discovery in 1898 and the structure was named after him as the Golgi apparatus.
- Many **scientists** did not believe that what Golgi observed was a real organelle and instead argued that the apparent body was a visual distortion caused by staining. The invention of the electron microscope in the

➢ **Faces of Golgi Apparatus:**

- Each Golgi stack has two distinct faces.
  (i) The 'cis' face is found near the endoplasmic reticulum.
  (ii) The 'trans' face is positioned near the plasma membrane.

➢ **Functions of Golgi Apparatus:**

- **Shipping Department of Cell:** The Golgi apparatus is the distribution and shipping department for the cell's chemical products.
- **Modification of Proteins & Lipids:** It modifies proteins and lipids that have been built in the endoplasmic reticulum and prepares them for export outside the cell or for transport to other locations in the cell.
- Small vesicles that contain proteins, carbohydrates, phospholipids and other molecules, bud off from the ER. These vesicles move through the cytoplasm until they reach the **'cis'** face of Golgi apparatus.
- The vesicles fuse with **Golgi apparatus** and release their molecules into it. Here, the compounds are further processed.
- **Formation of Conjugated Molecules:** Enzymes present in the Golgi lumen convert them into glycoproteins and glycolipids.

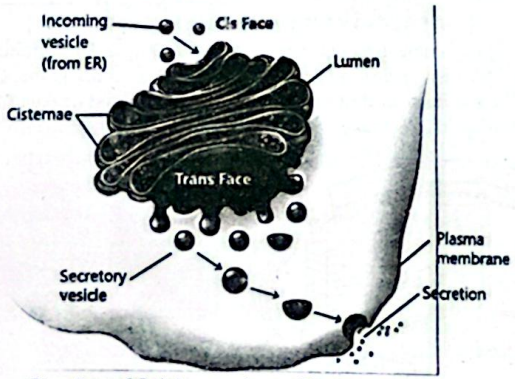


Figure: Structure of Golgi apparatus and its functioning

Check Understanding!

17. What is the primary function of centrioles in animal cells?

A. DNA replication
B. Protein synthesis
C. Spindle fiber formation during cell division
D. Energy production

➢ **Export of Materials:**

- The product is exported from the **'trans'** face of the Golgi apparatus in a vesicle and directed to its final destination inside or outside the cell.
- The exported products are known as **secretions.** Other products are returned to the endoplasmic reticulum or may undergo maturation to become lysosomes. In addition, the Golgi apparatus in plant cells produces pectin and other polysaccharides specifically needed for plant structure and metabolism.

Q. Describe the formation and functions of lysosomes. [Exercise L.Q.12]

(7) Lysosomes:

- **Single Membranous:** Lysosomes are spherical organelles bounded by a single membrane.
- **Act as Digestive Compartment:** They serve as digestive compartments of the cell.
- **Present in Abundance:** Lysosomes are found in most eukaryotic cells. In animals, they are most numerous in disease-fighting cells, such as white blood cells. This is because white blood cells must digest materials like bacteria, viruses, and other foreign intruders.

Discovery of Lysosomes

- Lysosomes were discovered by a Belgian scientist Christian René de Duve. They contain strong digestive enzymes.

➢ **Importance of Lysosomes:**

- They are also involved in breaking the cellular materials that have exceeded their lifetime or are no longer useful. In this regard, the lysosomes perform **autophagy.**
- **Break Cellular Wastes & Macromolecules:** They break down cellular waste products, fats, carbohydrates, proteins, and other macromolecules into simple compounds, which are then transferred back into the cytoplasm for making new materials.

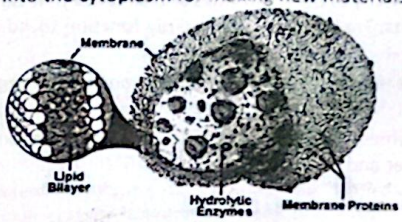


Figure: Structure of lysosome

Q. How Cells are Protected against lysosome enzymes?

- The cell is safe from the enzymes of lysosomes. These enzymes require acidic environment (of pH of about 4.8).
- The lysosomal matrix is acidic but cytosol is a neutral **environment.** So, even if a lysosome is ruptured, its digestive enzymes become inactive and the cell remains **uninjured.**

➢ **Enzymes Present in Lysosomes:**

- Lysosomes have about **40 different hydrolytic** enzymes, all of which are manufactured in the endoplasmic reticulum and modified in the Golgi apparatus.
- **Protect From Damage:** The membrane covering of the lysosome protects the rest of the cell from the **harsh digestive** enzymes contained in the lysosomes, which would otherwise cause significant damage.

Check Understanding!

18. How do microfilaments contribute to cell movement?

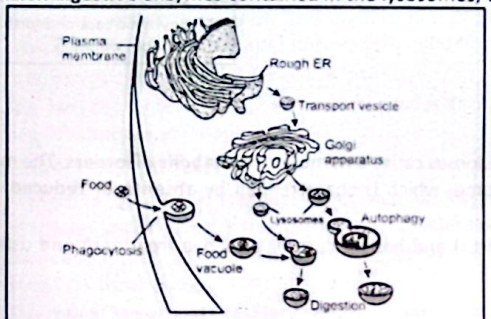


Figure: Role of lysosome in the breakdown of the phagocytosed particle and cellular component

Work of de-Duve on lysosomes

- In the mid-18th century, Belgian scientist **Christian** René de Duve was investigating carbohydrate metabolism in liver cells.
- He observed that when cells are damaged in the **centrifuge**, they release acid phosphatase. He suggested that this digestive enzyme was encased in some **membrane** bounded organelle within the cell, which he named as **lysosome.**

➢ **Diseases Caused by Lack of Lysosomal Diseases:**

- **Storage Diseases:** In lysosomal storage diseases the patient lacks one of the **hydrolytic enzymes** of lysosome. The abnormal lysosome fills with indigestible substances, which interfere with cellular functions.
- **Examples:**
  - (i) **Pompe's Disease:** lysosome lacks a **glycogen-digesting** enzyme. So, harmful amounts of glycogen accumulate in liver cells in this disease.
  - (ii) **Tay-Sachs Disease:** An essential lipiddigesting enzyme is missing. Accumulation of these lipids in the nerve cells of brain damages the **nervous system, causes mental retardation,** and **death** in early childhood.
- **Cause of Cell Death:** Lysosomes also function in the elimination of whole cell. Selective cell death is a mechanism used by multicellular organisms in their development.
- **Example:** When a **tadpole** develops into a frog, the cells of the tail are destroyed by the enzymes of lysosomes.

Important to Know

- Many cells in your brain die during development. This directed suicide is accomplished by the rupture of the **lysosomes** within the cells that are being eliminated.

(8) Peroxisomes:

- **Single Membranous:** Peroxisomes are single membrane bounded organelles in all eukaryotic cells.
- **Discovered By:** These were discovered by Christian de Duve, who also discovered lysosomes.

➢ **Enzymes Present in Peroxisome:**

- Peroxisomes contain a variety of **enzymes**. Many of these enzymes are oxidative that carry out oxidation i.e. the removal of electrons and hydrogens. These enzymes primarily function to rid the cell of toxic substances.
- **Detoxifications:** Peroxisomes, such as those in liver cells, detoxify alcohol and other harmful compounds by carrying out their oxidation.
- Some peroxisomes contain catalase enzymes, which break down hydrogen peroxide (a common byproduct of cellular metabolism) into water and oxygen.

$$\underset{\text{Hydrogen peroxide}}{2H_2O_2} \xrightarrow{\text{Catalase}} \underset{\text{Water}}{2H_2O} + \underset{\text{Oxygen}}{O_2}$$

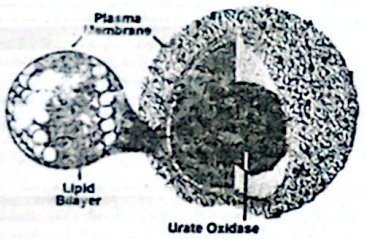


Figure: Structure of peroxisome

Check Understanding!

19. **Which of the following best describes the movement of cilia?**
A. Undulating like a wave
B. Rotary spinning
C. Rhythmic back-and-forth beating
D. Random vibration

➢ **Defects Due to Peroxisomes:**

- **Zellweger Syndrome:** Defects in peroxisomes cause a number of **metabolic disorders**. The most serious of these disorders is Zellweger syndrome, which is characterized by absence or **reduced number** of **peroxisomes** in the cells.
- It is congenital disorder (present at birth) and has no cure or effective treatment and usually causes death within the first year of life.

(9) Glyoxysomes

- Glyoxysomes are similar to **peroxisomes** but are found only in **plant cells.** These organelles contain enzymes that convert lipids into carbohydrates.

- They are most abundant in the cells of **lipid-rich seeds** (e.g. castor beans and soyabeans).
- During germination, these organelles convert stored lipids into carbohydrates that provide energy for seed germination.

(10) Vacuoles

- These are membrane-bounded sacs.
- **Functions of Vacuoles:** Vacuoles function in several ways.
- **Vacuole of Plant:** In mature plant cells, a single large vacuole provides structural support, as well as serves functions in storage, waste disposal, protection, and growth.
- **Vacuole in Animal:** Vacuoles in animal cells, however, are much smaller, and are more commonly used to temporarily store materials or to transport substances.

Recalling

- Vacuoles are fluid filled single membrane bounded organelles. Cells have many small vacuoles in their cytoplasm.
- However, when a plant cell matures its small vacuoles fuse to form a single large vacuole.

➢ **Formation of Central Large Vacuole:**

- Many plant cells have a large, single central vacuole. This large vacuole slowly develops by fusion of smaller vacuoles. It takes up most of the space in the cell **(80 percent or more)**. The vacuole in plant cells is enclosed by a membrane called tonoplast.
- **Cell Sap:** The material inside the vacuole is called cell sap. The cell sap differs markedly from the surrounding cytoplasm.
- The central vacuole in plant cells plays an important structural role for the plant. This role of the vacuole is related to its ability to control turgor pressure.
- **Turgor Pressure:** Turgor pressure makes the rigidity of the cell.
- Under optimum conditions, a plant receives adequate amounts of water and the centrai vacuoles of its cells swell as the **liquid collects** within them. It creates a high turgor pressure, which helps to maintain the structural integrity of the plant, along with the support from the cell wall.
- **Vacuoles Store Pigments:** Vacuoles also often store the pigments that give certain **flowers their colours**, which aid them in the attraction of bees and other pollinators.
- **Vacuoles Release Poisons:** Vacuoles also release molecules that are poisonous to various insects and animals, thus discouraging them from **consuming** the plant.

- Several materials commonly stored in plant vacuoles have been found to be useful for humans, **such as opium**, rubber, and garlic flavouring.

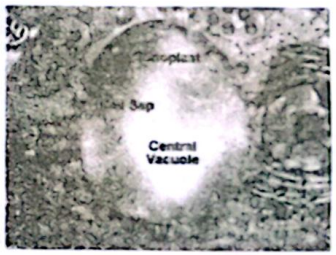


Figure: Structure of vacuole in plant cell

(11) Centrioles

- In the cells of **animals** and most protists, centrioles are organelles associated with the assembly and organization of the fibres of cytoskeleton i.e., microtubules (including spindle fibres).
- In eukaryotic cells centrioles occur in pairs.
- The two centrioles are located at right angles to one another near the nuclear envelope.

Recalling

- Centrioles are hollow and cylindrical **organelles**. A centriole is made of nine triplets of microtubules.

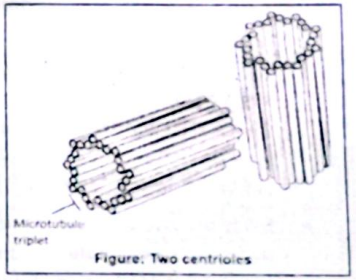


Figure: Two centrioles

➢ **Importance of Centrioles:**

- **Formation of Cilia + Flagella:** In ciliated or flagellated cells centrioles are involved in the formation of cilia and flagella.
- **Basal Body:** Each cilium and flagellum is anchored by a centriole, known as basal body.
- The cells of plants and fungi **lack centrioles** and **basal bodies**, and their microtubules and spindle fibres are organized from the structures of cytoplasm.

Q. Describe the structures of the three fibres that make the cytoskeleton.

(12) Cytoskeleton

It is a network of protein fibres present in cytoplasm. Cytoskeleton includes the following types of fibres.

i. **Microfilaments:**
- These are present in all eukaryotic cells.
- **Structure:** Microfilaments are solid rods made of a globular protein, called actin.
- **Importance:** Microfilaments disassemble and reassemble and help the cells to change shape and move. Microfilaments also enable a dividing cell to pinch off into two cells. In association with myosin, microfilaments help in cellular contraction.

Check Understanding!
20. How does the 9+2 arrangement contribute to the function of motile cilia?

ii. **Microtubules:**
- These straight, hollow cylinders are composed of subunits. Each subunit is made of two different tubulin proteins known as **alpha-tubulin** and **beta-tubulin.**
- Microtubules give structure and shape to a cell.
- They also serve as **highways** for the transport of organelles. Moreover, microtubules are the major components of **cilia and flagella.**
- They participate in the formation of spindle fibres during cell division.

iii. **Intermediate Filaments:**
- These are found only in some **higher animal groups.**
- They are made of different proteins but the most common type of protein subunit is vimentin. Some cells may have intermediate filaments made of other proteins.
- Example: Skin cells contain a protein keratin.
- Importance: Intermediate filaments maintain **cell shape** and rigidity, and serve to anchor several organelles, including the nucleus.

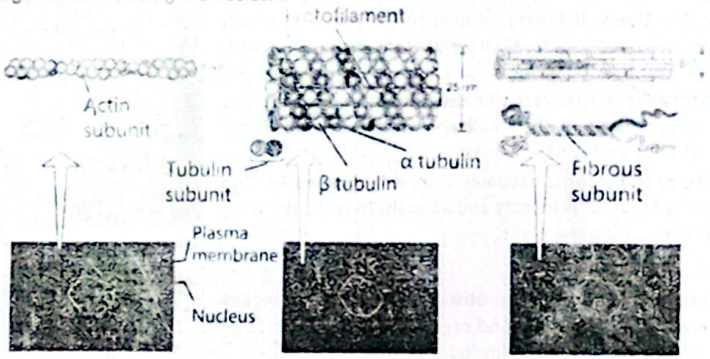


Figure: Components of cytoskeleton

(13) Cilia and Flagella

- **Cilium** (plural cilia) and **flagellum** (plural flagella) are the **locomotory** appendages that protrude from certain cells.
- **Thin + Tail Like:** They are thin, tail-like projections extending from the cell body.
- Cilia are short in length and are usually numerous in number; while flagella are longer but less numerous in number. Cilia are rare in plants.
- Many protozoans (ciliates) **possess cilia.** Larger eukaryotes such as mammals have cilia on some cell surfaces. **For example,** in humans, cilia are found in the lining of the trachea where they sweep mucus and dirt out of breathing tubes.

- **Axoneme:** The core of eukaryotic cilia and flagella is called axoneme. It contains two **central microtubules** that are surrounded by an outer ring of nine doublet **microtubules.** Dynein molecules are located around the circumference of the axoneme. These dynein molecules **bridge the gaps** between adjacent microtubule doublets.
- Biologists refer to this organization as a **"9 + 2"** structure.
- A plasma membrane surrounds the entire axoneme.

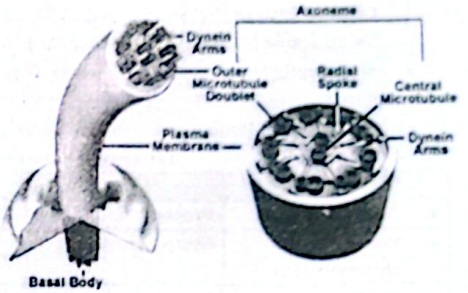


Figure: Structure of eukaryotic cilium and flagellum

➢ Basal Body of Cilium:

- **Basal Body:** At the base of the cilium its organising centre, called basal body, is present.
- **Basic Component of Basal Body:** Basal body has the same basic structure of the outer **ring of axoneme,** but each of the nine sets of outer filaments is composed of **three microtubules,** rather than a **doublet of microtubules.**
- The basal body is actually the **centriole.** Prokaryotic flagella have a completely different structure built from the **protein flagellin.**

PROKARYOTIC AND EUKARYOTIC CELLS

- **Bacteria and archaea** are made of prokaryotic cells.
- All forms other than bacteria & archae are composed of eukaryotic cells.
- Both **prokaryotic and eukaryotic** cells have DNA as their genetic material; both have plasma membranes as their coverings; and both have ribosomes for protein synthesis.

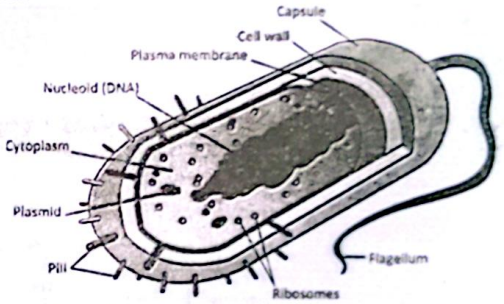


Figure: Structure of a generalized prokaryotic cell

➢ Characteristics of Prokaryotes:

- Prokaryotic cells are much **simpler** than eukaryotic ones.
- **Size of Cell:** Most prokaryotic cells range from **2 to 8μm** in length i.e., about one-tenth of the size of a typical eukaryotic cell.
- **Lack Nucleus:** A prokaryotic cell lacks a nucleus. The much less extensive DNA of prokaryotic cell is present in the more-or-less central region known as **nucleoid** (nucleuslike).
- **Lack Membranous Organelles:** A prokaryotic cell also lacks other membrane-bounded organelles like endoplasmic reticulum, mitochondria, chloroplasts, Golgi apparatus, lysosomes, peroxisomes etc. The entire cytoplasm of a prokaryotic cell is one unit with no internal support structures.
- **Smaller Ribosomes:** Ribosomes are present in prokaryotic cell but these are smaller in size than those of eukaryotic cells.

➢ Svedberg Values of Ribosomes:

- The Svedberg values (sedimentation rates) of the smaller and larger subunits of ribosomes of prokaryotic cells are **30S and 50S respectively.** The sedimentation rate of a complete **ribosome is 70S.**
- **Cell Wall of Prokaryotic Cell:** Surrounding the plasma membrane of most prokaryotic cells is a cell wall but it does not contain cellulose. It composed of peptidoglycan that is a single large polymer of amino acids and sugar.

- **Capsule + Pili:** In bacteria the cell wall may also be surrounded by a capsule and may also have extensions for attachment known as pili (singular pillus).
- **Prokaryotic Flagella:** They are made of repeating units of the protein flagellin and they do not contain microtubule triplets.
- **Cell Division:** Mitosis and meiosis are missing in prokaryotic cell and it divides by direct division (binary fission).

Difference between Eukaryotic and Prokaryotic cells

Characteristics	Eukaryotic Cell	Prokaryotic Cell
Distinct Nucleus	Present	Absent
Number of chromosomes	More than one	One--but not true chromosome: Plasmids
Cell Type	Usually multicellular	Usually unicellular (some cyanobacteria may be multicellular)
Example	Protozoans, Algae, Fungi, Animals, Plants	Bacteria and Archaea
Lysosomes and peroxisomes	Present	Absent
Microtubules	Present	Absent or rare
Endoplasmic reticulum	Present	Absent
Mitochondria	Present	Absent
Cytoskeleton	Present	May be absent
Vacuoles	Present	Present
Ribosomes	Larger	Smaller
Golgi apparatus	Present	Absent
Chloroplasts	Present (in plants)	Absent; chlorophyll scattered in the cytoplasm
Cell Division	Mitosis or meiosis	Mitosis and meiosis are missing; cell divides by direct division (binary fission)
Flagella	Membrane bounded; contains two central microtubules surrounded by an outer ring of nine doublet microtubules	Not membrane bounded; made of repeating units of flagellin; do not contain microtubule triplets
Cell wall	Only in plant cells and fungi (chemically simpler)	Composed of peptidoglycan (a single large polymer of amino acids and sugar)
Cell size	10-100 um	1-10 um

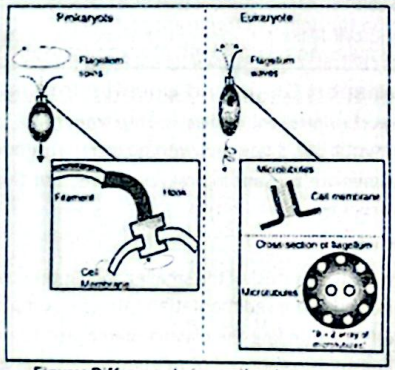


Figure: Difference between the structures of prokaryotic and eukaryotic flagella

CELL SIGNALLING

- **Cell Signalling:** The ability of cells to respond to stimuli or changes occur in environment producing cellular responses is called **cell signalling.**
- **Importance:** It involves the transmission of signals between cells through a series of molecular events, often leading to a cellular response.

Steps of Cell Signalling: (Mechanism of Cell Signalling)

(i) Signal Reception:

- Cell signalling begins when a signal molecule **(ligand)** binds to a receptor on the membrane of a target cell. These receptors are typically **proteins** embedded in the cell membrane but can also be located inside the cell. Each receptor is specific to a particular ligand.
- **Ligand:** A molecule that binds to a specific receptor, triggering a cellular response or signaling pathway.

(ii) Signal Transduction:

- Once the receptor binds to the **ligand,** it undergoes a **conformational change** (change in shape or structure) that activates an intracellular signalling pathway. This often involves a series of interactions and modifications, creating a signalling chain or sequence that increases the signal. Small molecules like cAMP (cyclic AMP), calcium ions, and **inositol triphosphate** (IP3) can act as second messengers, transmitting the signal from the receptor to target molecules **inside** the cell.

> • **Signal Transduction:** A process by which a cell converts an external signals into a specific cellular response often through a series of molecular interaction.

(iii) Cellular Response:

- The **signal transduction** pathway often leads to changes in **gene expression, turning specific genes** on or off. This can result in various cellular responses, such as cell growth, division, differentiation, or apoptosis (programmed cell death).
- Signalling can also lead to changes in cellular metabolism, enzyme activity, or the opening and closing of ion channels.

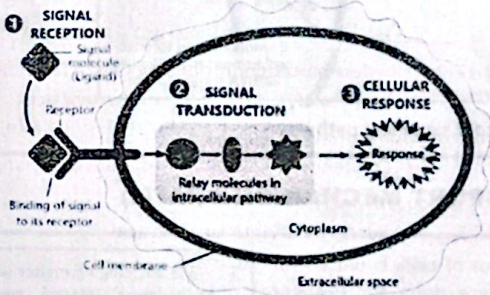


Figure: Steps of cell signalling

Check Understanding!

21. Where are adult stem cells (ASCs) commonly found?

A) Umbilical cord only
B) Embryo
C) Tissues like bone marrow and skin
D) Brain only

Q. Describe the pathway of protein signal and steroid signal from outside of a cell to inside. Exercise L.Q.15

Pathways of Cell Signals from Outside to Inside

Cell signalling pathways involve the transmission of signals from the cell's exterior to its interior, resulting in a specific cellular response.

Main Types of Signalling Pathway:

There are two main types of signalling pathways based.

(i) Protein/Peptide Signalling: (Water Soluble)

- Protein or peptide signalling molecules are **water-soluble**, so they cannot pass through plasma membrane. When such ligand approaches the cell surface, it binds to its specific receptor on plasma membrane. This binding causes a conformational change in the receptor protein and activates it.
- The **activated receptor** triggers a series of reactions within the cell. These reactions generate second messenger like cyclic AMP (cAMP) which starts changes e.g., changes in gene expression. The pathway can lead to **changes in metabolism**, cell growth, division, or apoptosis.

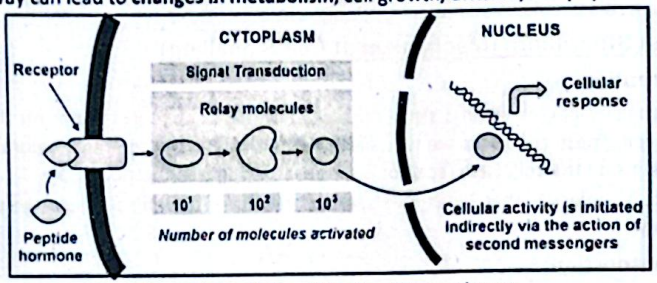


Figure: Protein/peptide signalling pathway

(ii) Steroid Signalling: (Lipophilic: Lipids Loving)

- Steroid hormones, being **lipophilic**, can diffuse through the **plasma membrane** of the target cell.
- They bind to **specific intracellular receptors** located in the cytoplasm or nucleus, then binding results in the formation of active **receptor-hormone complex (RHC)** which moves into the nucleus if it was not already there.
- Inside nucleus, the receptor-hormone complex binds to specific DNA sequences in target genes.
- This binding regulates the transcription of these genes, leading to increased or decreased production of specific proteins.

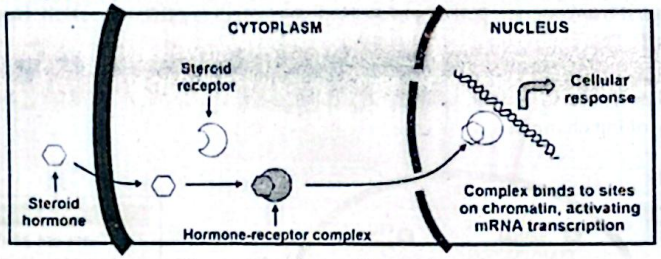


Figure: Steroid signalling pathway

MEMBRANE TRANSPORT MECHANISMS (MTM)

- The movement of **substances** in and out of cells is crucial for cellular functions. These movements are done for nutrient uptake, waste elimination, gas exchange, and signal transduction.
- Cells rely on the **plasma membrane** for regulating the movement of substances in and out of the cell.

- While **exchanging** matter with cell environment, plasma membrane maintain equilibrium inside the cell as well as outside.

➢ **Importance of Membrane Transport Mechanism:**

- **Membrane transport** mechanisms are essential processes that enable the cell to **maintain homeostasis**, **acquire nutrients**, **remove waste products**, and **communicate** with its environment.

➢ **Types of Membrane Transport Mechanism:**

- These mechanisms include two mechanisms i.e., passive transport (which requires no energy input) active transport (which utilizes energy).

(1) Passive Transport

Definition: The movement of molecules across plasma membrane without any expenditure of energy is called passive transport.

Check Understanding

22. What is the main limitation of adu stem cells compared to embryon ones?

➢ **Types of Passive Transport:**

The following are the types of passive transport.

(i) Diffusion

- **Definition:** The net movement of a substance (liquid or gas) from an area of **higher concentrati** to one of lower concentration is called **diffusion.**
- Because a cell does not expend energy when molecules diffuse across its membrane, the diffusio of molecules is a type of **passive transport.**

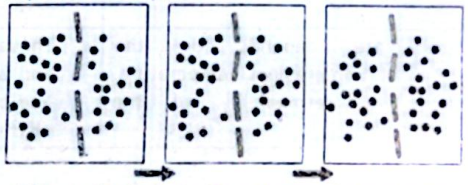


Figure: Diffusion of two types of molecules

(ii) Facilitated Diffusion

- **Definition:** A Type of **passive transport** in which molecules are transported across the membrane with the help of carrier proteins located at plasma membrane.
- When a transport protein helps a substance to move it down its concentration gradient (from higher to lower concentration), the process is called **facilitated diffusion.** It is also a type of passive transport because **no energy** is used in facilitated diffusion. The rate of facilitated diffusion depends on how many transport-protein molecules are available in the membrane.

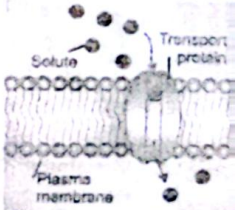


Figure: Facilitated diffusio

➢ **Proteins Involve in Facilitated Diffusion:**

- The main types of transport proteins involved in facilitated diffusion are:
  (a) Channel Proteins (b) Carrier Proteins

(a) Channel Proteins:

- The proteins which form **hydrophilic channels** across the membrane that allow specific molecule or ions to **pass through.**
- They can be **gated** or **non-gated.** Gated channels open or close in response to specific stimuli (such as voltage changes, ligand binding, or mechanical stress).
- **Examples:** Include ion channels (allow the passage of specific ions e.g., Na^+, K^+, Ca^{2+}, Cl^-) and aquaporins which facilitate the rapid transport of water molecules.

(b) Carrier Proteins (Transporters):

- The proteins which bind to the **specific molecule** they transport, undergo a conformational change and move the molecule across the membrane.
- They are highly specific for the molecule they transport.
- They can become saturated, meaning there is a maximum rate of transport when all carrier protein are occupied.
- **Examples:** Glucose transporters which facilitate the transport of glucose.
- **Amino Acid Transporters:** Transport specific amino acids into or out of the cell.

Difference between Simple and Facilitated Diffusion

	Simple Diffusion	Facilitated Diffusion
Mechanism	• Substances move from higher concentration to lower concentration directly through the lipid bilayer of plasma membrane.	• Substances move from higher concentration to lower concentration through specific transport proteins embedded in plasma membrane.
i. Energy Requirement	• It is a passive transport mechanism, requiring no energy input from cell.	• It is also a passive transport mechanism and does not require energy.
ii. Types of Molecules	• **Non-polar:** Typically involves small, nonpolar molecules such as oxygen, carbon dioxide, and lipid-soluble substances.	• **Polar:** Primarily involves polar or charged molecules, such as glucose, amino acids, and ions, which cannot easily pass through the hydrophobic core of the lipid bilayer.
iii. Rate of Movement	• The rate depends on the concentration gradient, temperature, and the permeability of the membrane.	• The rate can be affected by the number and availability of transport proteins and can reach a maximum rate when all transport proteins are saturated.

(iii) Osmosis

- **Definition:** The process by which water molecules diffuse across a cell membrane from an area of higher concentration to an area of lower concentration is called osmosis.
- **No Energy Required:** Because water is moving from a higher to lower concentration, osmosis does not require cells to expend energy. Therefore, osmosis is the passive transport of water.
- **Direction of Osmosis:** The direction of osmosis depends on the concentration of solutes on the two sides of membrane. Water always moves from hypotonic solution (with **lower solute concentration**) hypertonic solution (with higher solute concentration).
- Osmosis occurs through selectively permeable membrane, which allows water to pass while restricting many solutes.

Tonicity

- The term **tonicity** refers to the relative concentration of solutes in the solutions.
- **Hypertonic solutions:** In which more solute is present.
- **Hypotonic solutions:** In which less solute is present.
- **Isotonic solutions:** Which have equal concentrations of solutes inside & outside.

➢ Importance of Osmosis:

- **Maintain Turgor Pressure:** Osmosis is crucial for **maintaining cell turgor**, which is vital for plant cells, and for balancing the internal water content in cells.
- The direction and rate of osmosis are influenced by the osmotic gradient and the permeability of the membrane to water.
- **Aquaporins:** Specialized proteins called aquaporins facilitate the rapid transport of water molecules across the cell membrane, ensuring efficient regulation of **cellular hydration and volume.**

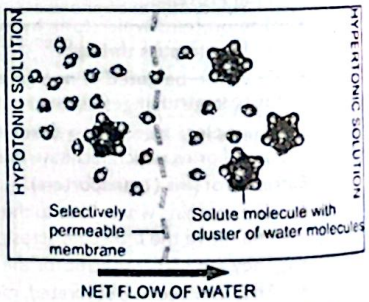
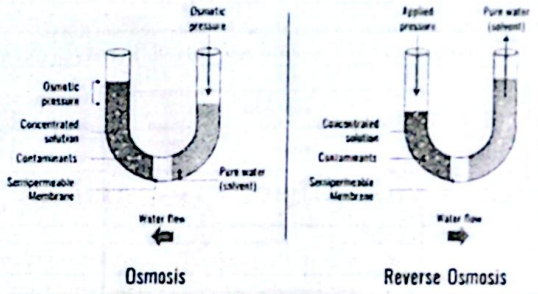


Figure: Osmosis at molecular level

Reverse Osmosis (RO)

- A widely used technology for **purifying water** by removing contaminants and impurities is called **reverse osmosis.**
- Unlike natural osmosis, which moves water from a lower to a **higher solute concentration**, reverse osmosis applies external pressure to push water through a semi-permeable membrane from a higher to a lower solute concentration. This process effectively filters out dissolved salts and other impurities, providing clean and safe drinking water.
- **Use of RO:** Reverse osmosis is commonly used in water treatment plants, desalination facilities, and even in household water **purification systems.**



(iv) Active Transport

- **Definition:** The movement of substances across plasma membrane from lower concentration to higher concentration with the expenditure of energy is known as **active transport.**

➢ Types of Active Transport:

Following types of active transport occur through plasma membrane.

(a) Active Transport Through Carrier Proteins

- In this process, carrier (transport) proteins in the plasma membrane use energy to move the molecules against the concentration gradient.
- **Example:** The membranes of nerve cells have carrier proteins in the form of **"sodium-potassium pump".**
- In a resting (not conducting nerve impulse) nerve cell, this pump spends energy (ATP) to maintain higher concentrations of K^+ and lower concentrations of Na^+ inside the cell. For this purpose, the pump actively moves Na^+ to the outside of the cell and K^+ to the inside of the cell.

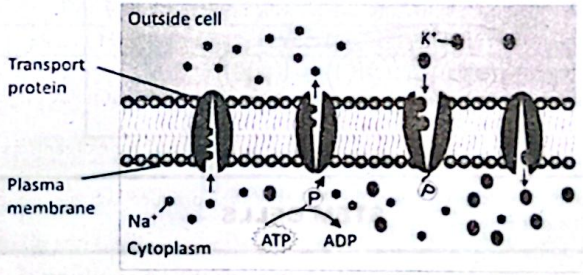


Figure: Active transport through carrier proteins

(b) Endocytosis

- In endocytosis, bulky materials are **moved into** the cell across plasma membrane. During endocytosis a portion of plasma membrane invaginates (depressed inward). The material from outside is taken inside the invagination, and its ends seal. Thus, a small vesicle is formed. It detaches from the plasma membrane and moves into cytoplasm.

➢ **Types of Endocytosis:**

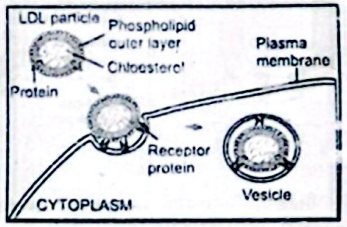
The two common forms of endocytosis are: (i) Phagocytosis (ii) Pinocytosis

(i) Phagocytosis: In phagocytosis cell takes in **solid material.**

(ii) Pinocytosis: In pinocytosis cell takes in liquids in the form of droplets.

Receptor-Mediated Endocytosis

- Specific receptor proteins of plasma membrane pick up material from outside and pinch inside to form a vesicle.
- **Example:** The cells of liver have receptor proteins for cholesterol.
- Cholesterol circulates in our blood in the form of low-density-lipoproteins (LDLs).
- The receptor proteins of plasma membrane of liver cells, recognize and take up LDLs from the blood by receptor-mediated endocytosis.



(c) Exocytosis:

- **Definition:** A process through which **bulky material** is exported out of cell is called **exocytosis.**
- In exocytosis, the bulky material is packed inside a membrane and a vesicle is formed.
- The vesicle moves to the **plasma membrane** and fuses with it to release its contents into the **extracellular environment.**

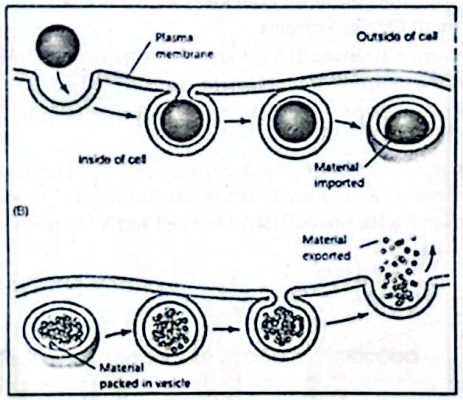


Figure: (A) Endocytosis, (B) Exocytosis

STEM CELLS

- **Stem Cells:** The cells which have remarkable ability to develop into many different cell types in the body are called **stem cells.**

➢ **Mechanism To Produce New Cells:**

- When a stem cell divides, each **new cell** has the potential either to remain a stem cell or to become specialized cell.
- **Examples:** Such as a muscle cell, a red blood cell, or a brain cell.

Q. Categorize and explain different types of stem cells. Exercise L.Q.16

➢ **Major Categories of Stem Cell: (On the Basis of Types of Cell)**

The following are the major categories of stem cells on the basis of the number of types of cells which they can make.

i. **Totipotent:** A type of stem cells which can differentiate into **all possible cell types.**
Example: Zygote and the cells produced by the first few divisions in zygote.

ii. **Pluripotent:** These cells can turn into almost **any cell.**
Example: Cells from the early embryo.

iii. **Multipotent:** These cells can differentiate into a closely related family of cells.
Example: The hematopoietic stem cells can become red and white blood cells or platelets.

iv. **Oligopotent:** The type of stem cells which can differentiate into a few different cell types.
Example: Adult lymphoid or myeloid stem cells.

v. **Unipotent:** The sem cells which can only produce cells of one kind, which is their own type. However, they are still stem cells because they can renew themselves.
Example: Adult muscle stem cells.

➲ Uses of Stem Cells

i. **Regenerative Medicine:** Stem cells have the potential to repair or replace damaged tissues and organs. Therefore, they are used for treating conditions such as spinal cord injuries, type 1 diabetes, Parkinson's disease, and heart disease.

ii. **Drug Testing and Development:** By differentiating stem cells into specific cell types, researchers can create models of human diseases, allowing for more accurate testing of drug effects and reducing the reliance on animal models.

iii. **Personalized Medicine:** Stem cells can be derived from a patient's own cells, reducing the risk of immune rejection when used in treatments. This personalized approach can lead to more effective and safer therapies.

➲ Categories of Stem Cells: (On the Basis of Their Origin)

The following are the major categories of stem cells on the basis of their origin.

(i) Embryonic Stem Cells (ESCs):

- **Origin:** ESCs are derived from the inner cell mass of blastocysts (early-stage embryos).
- These stems cells are pluripotent, meaning they can differentiate into nearly all cell types in the body.
- **Characteristics:** They have high differentiation potential, making them extremely versatile for research and therapy.
- **Ethical Issues:** Ethical concerns of using ESCs include the use of human embryos, risk of teratoma formation, and potential immune rejection.

(ii) Adult Stem Cells (ASCs)

- **Occurrence:** These stem cells are found in various tissues throughout the body, such as bone marrow, fat, and blood.
- They are multipotent, meaning they can differentiate into a limited range of cell types related to their tissue of origin.
- **Less Ethical Issue:** Using them involves less ethical controversy, lower risk of immune rejection when derived from the patient's own tissues.
- **Limitation:** They have limited differentiation potential and are harder to isolate and culture.

Q. What are the advantages and disadvantages of using induced Pluripotent Stem Cells? Exercise L.Q.17

(iii) Induced Pluripotent Stem Cells (iPSCs)

- **Synthesis or Origin:** They are generated in the lab by **reprogramming** adult somatic cells to a pluripotent state using specific transcription factors. They are pluripotent, similar to embryonic stem cells.

- **Advantages of Using iPSCs:** They do not have the ethical controversies linked to embryonic ste cells, as they do not require the destruction of embryos.
- **Origin:** They can be generated from a patient's own cells, minimizing the risk of immune rejectio
- **Uses:** They offer potential for regenerating damaged tissues and organs (e.g., new heart cells patients with heart disease or new neurons for patients with neurodegenerative conditions).
- **Disadvantages of using iPSCs:** The reprogramming process can introduce genetic changes that m affect iPSCs.
- **Effects:** They could form tumours (teratomas) when transplanted into patients. Directing iPSCs differentiate into specific, fully functional cell types remains a complex task.
- It is still difficult to ensure that these cells function properly.

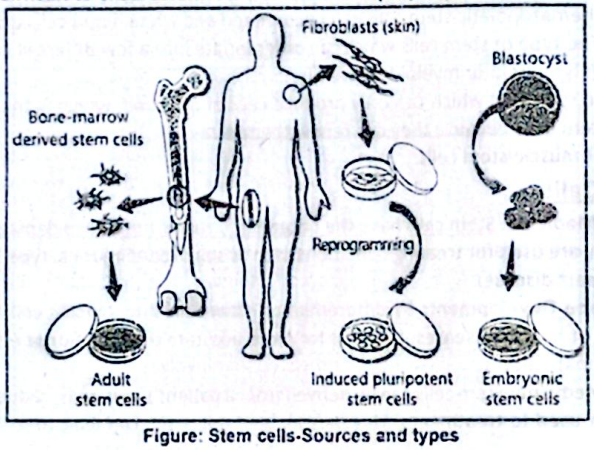


Figure: Stem cells-Sources and types

Check Understanding (Solutions)

Sr. #	Option	Explanation
1.	B	• These are signs of life: movement, energy use, and growth.
2.	S.Q	• He stated that new cells come only from existing cells, supporting the third part of the ce theory.
3.	C	• Light microscopes are limited by the wavelength of visible light, which restricts the maximum magnification to about 1000 – 1500x and resolution to 200 nanometers.
4.	S.Q	• **TEM (Transmission Electron Microscope):** It provides detailed images of the interna structures of thin cell sections. • **SEM (Scanning Electron Microscope):** It produces 3D images of the surface of specimen by scanning them with electrons. • **Main Difference:** TEM looks inside the cell, while SEM looks at the surface.
5.	B	• The middle lamella is the outermost layer found between the primary cell walls of adjacen plant cells and composed of pectin, a sticky polysaccharide, which functions to "glue" cel together, providing mechanical strength and cohesion to plant tissues.
6.	S.Q	• **Primary Cell Wall:** Thin, flexible, and mainly made of cellulose; forms during cell growth • **Secondary Cell Wall:** Thicker, stronger, and contains cellulose, hemicellulose, and lignin forms after the cell stops growing. • **Function:** Secondary walls add mechanical strength and support, especially in wood plants.
7.	B	• Protein channels and carriers in the plasma membrane enable selective transport b recognizing and transporting specific molecules, ensuring controlled entry and exit.

8.	S.Q	• Integral proteins act as channels and carriers for specific molecules. • Cholesterol in the membrane maintains fluidity and stability. • The selective permeability allows nutrients in and waste out. • It enables cell signalling and communication in multicellular organisms.
9.	C	• The cytosol is the fluid portion of the cytoplasm where organelles are suspended and cellular activities occur--just like land supports a city's infrastructure.
10.	S.Q	• TEM transmits electrons through thin sections of the membrane, producing high-resolution images that reveal its layered structure and embedded proteins.
11.	B	• The nuclear envelope has nuclear pores that regulate transport of RNA, proteins, and other molecules.
12.	S.Q	• **Nuclear pores** allow regulated exchange of molecules between the nucleus and cytoplasm. • They are vital for RNA export, protein import, and nuclear-cytoplasmic communication. • Without them, essential gene expression processes would be disrupted.
13.	C	• The nucleolus is responsible for synthesizing rRNA and assembling ribosomal subunits.
14.	S.Q	• The perinuclear space is the gap between the inner and outer membranes of the nuclear envelope. • It is continuous with the lumen of the endoplasmic reticulum. • It plays a role in transport and membrane communication between the nucleus and ER.
15.	D	• The sternal (cisternal) space belongs to the ER, not the mitochondria.
16.	S.Q	• It synthesizes lipids and steroid hormones. • It detoxifies drugs and toxins, especially in liver cells. • It regulates calcium ion storage, critical in muscle function. • It also contributes to carbohydrate metabolism in some cells.
17.	C	• Centrioles organize microtubules to form the mitotic spindle, crucial during mitosis.
18.	S.Q	• Through actin polymerization and interaction with myosin, they enable cellular extensions and contractions.
19.	C	• Cilia move substances by coordinated, rhythmic beats, such as clearing mucus from the respiratory tract.
20.	S.Q	• The 9+2 arrangement of microtubules supports efficient, coordinated movement by allowing dynein arms to generate force for bending.
21.	C	• ASCs are multipotent cells located in specific tissues and help in repair and regeneration.
22.	S.Q	• **Multipotency:** ASCs can only form a limited range of cells related to their tissue. • **Examples:** Bone marrow stem cells mostly become blood cells. • **Limitation:** This restricts their use in forming other body tissues. • **Ethics:** They don't raise ethical issues like ESCs. • **Immune Compatibility:** They're less likely to cause rejection in transplants.

Exercise

Exercise — MULTIPLE CHOICE QUESTIONS (MCQs) — Section 01

1. Which one of the following eukaryotic cell structures does not contain DNA?
   (a) Nucleus (b) Mitochondrion (c) Endoplasmic reticulum (d) Chloroplast
2. Which of the following is not an accurate description of a chromosome?
   (a) It is a coloured body localized in the nucleus
   (b) It is a protein and nucleic acid complex
   (c) It is the cellular structure that contains the genetic material
   (d) In eukaryotes, it is composed of many DNA molecules attached end to end
3. A centriole is an organelle that is:
   (a) Present in the centre of a cell's cytoplasm
   (b) Composed of microtubules and important for organizing the spindle fibres
   (c) Surrounded by a membrane
   (d) Part of a chromosome
4. The rough endoplasmic reticulum is:
   (a) An intracellular single-membrane system to which ribosomes are attached
   (b) An intracellular membrane that is studded with microtubular structures
   (c) A membranous structure found within mitochondria
   (d) Only found in prokaryotic cells
5. In the nucleus of eukaryotic cells, the genetic material is complexed with protein and organized into linear structures called:
   (a) Centrioles (b) Histones (c) Chromosomes (d) Plasmids
6. Which of the following statements does not apply to the nuclear envelope?
   (a) It is a double membrane
   (b) It is continuous with the endoplasmic reticulum
   (c) It has pores through which material enters and leaves
   (d) It has infoldings to form cristae
7. Lysosomes are formed by budding from which cellular organelle?
   (a) Smooth endoplasmic reticulum (b) Golgi apparatus
   (c) Rough endoplasmic reticulum (d) Nucleus
8. All peroxisomes carry out this function:
   (a) Break down fats and amino acids into smaller molecules that can be used for energy production in mitochondria
   (b) Digest macromolecules using the hydrolytic enzymes they contain
   (c) Synthesize membrane components such as fatty acids and phospholipids
   (d) Control the flow of ions into and out of the cell
9. How would the absence of peroxisomes in a cell affect its metabolism, and what would be the likely symptoms?
   (a) The cell would be unable to carry out oxidative phosphorylation, leading to reduced ATP production.
   (b) The cell would accumulate hydrogen peroxide, leading to oxidative stress and potential cellular damage.
   (c) The cell would have impaired protein synthesis, leading to muscle weakness.
   (d) The cell would fail to produce lipids, causing membrane instability
10. Which of the following does not apply to chloroplasts?
   (a) They contain chlorophyll and the enzymes required for photosynthesis.
   (b) They contain an internal membrane system consisting of thylakoids.
   (c) They synthesize ATP.
   (d) They are bounded by two membranes, the inner of which is folded into the cristae.

11. What is the correct sequence of membrane compartments through which a secretory protein moves from synthesis to release from the cell?
   (a) SER → Golgi apparatus → RER → Cell membrane
   (b) Cell membrane → Golgi apparatus → RER → SER
   (c) RER → Golgi → Cell membrane → SER
   (d) RER → SER → Golgi apparatus → Cell membrane
12. How does the process of facilitated diffusion differ from active transport?
   (a) Facilitated diffusion requires energy, active transport does not
   (b) Facilitated diffusion does not require energy, active transport does
   (c) Both processes require energy
   (d) Both processes do not require energy

Answer Key with Explanations

Sr.No.	Option	Answer	Explanations
1.	(c)	Endoplasmic reticulum	• ER is involved in protein and lipid synthesis but does not contain DNA.
2.	(d)	In eukaryotes, it is composed of many DNA molecules attached end to end	• Eukaryotic chromosomes consist of a single, long DNA molecule, not many attached end-to-end.
3.	(b)	Composed of microtubules and important for organizing the spindle fibres	• Centrioles are made of microtubules and play a key role in cell division.
4.	(a)	An intracelliular double-membrane system to which ribosomes are attached	• RER has ribosomes on its surface and is involved in protein synthesis.
5.	(c)	Chromosomes	• Chromosomes are DNA-protein complexes found in the nucleus, organized for cell division and function.
6.	(d)	It has infoldings to form cristae	• Cristae are structures in mitochondria, not in the nuclear envelope.
7.	(b)	Golgi apparatus	• The Golgi apparatus packages and buds off lysosomes containing digestive enzymes.
8.	(a)	Break down fats and amino acids into smaller molecules that can be used for energy production by mitochondria	• Peroxisomes break down fatty acids and amino acids, producing hydrogen peroxide, which is then detoxified.
9.	(b)	The cell would accumulate hydrogen peroxide, leading to oxidative stress and potential cellular damage	• Peroxisomes break down hydrogen peroxide; without them, it accumulates and causes oxidative stress and cellular damage.
10.	(d)	They are bounded by two membranes, the inner of which is folded into the cristae.	• Chloroplasts do not have cristae; cristae are folds of the inner membrane of mitochondria, not chloroplasts.
11.	(d)	RER → SER → Golgi apparatus → Cell membrane	• Proteins are synthesized in the RER → transported to SER → modified in Golgi apparatus → secreted via cell membrane.
12.	(b)	Facilitated diffusion does not require energy, active transport does	• Facilitated diffusion is passive (no energy), while active transport requires energy to move substances against their gradient.

Exercise

SHORT ANSWER QUESTIONS

Section 02

Q.1 Compare the resolution and magnification of light microscope and electron microscope?

Ans.

Characteristics	Light Microscope	Electron Microscope
(i) Magnification Power	• Lower magnification (usually 500X to 1500X) than an electron microscope	• Higher magnification (direct magnification is 16000X and photographic magnification is 1000000X)
(ii) Resolution Power	• Low resolution (may be 0.2μm)	• High resolution (may be 0.2nm)

Q.2 State the cell theory. How we can validate it? What are the exceptions to cell theory?

Ans. Essential Points of Cell Theory:

i. All living organisms are composed of one or more cells.
ii. Cells are the basic units of structure and function in an organism.
iii. Cells come only from the division of pre-existing cells.

Validation of Cell Theory:

Cell theory can be validated through several **observations and experiments.**

(i) **By Using Microscopes:** By using light microscopes and electron microscopes, scientists visualize ce structures and find tangible (Physical/Real) evidence that cells are indeed the structural units of all livin organisms.

(ii) **By Using Techniques:** Through techniques like **live-cell imaging and genetic studies,** scientists can tra how cells replicate and give rise to new cells.
- These techniques validate the principle that all cells originate from **pre-existing cells.**

(iii) **By Using DNA Sequences:** Techniques like DNA sequencing reveal that cells share common gene material and metabolic pathways, reinforcing the notion that the cell is the fundamental unit of life.

(iv) **By Using Experiments:** Such as **cell culture** studies and tissue engineering, validate cell theory b demonstrating cellular growth, differentiation, and **reproduction.**

Exceptions to Cell Theory:

While cell theory is widely **accepted,** there are notable exceptions (Excluded).

(i) **Viruses + Viroid + Prions:** Viruses challenge cell theory because they are not made of cells and cannot carry out life processes independently. They require a **host** cell to replicate and are considered by man scientists to be at the border of living and non-living entities. Similarly, **prions** and viroids sho properties of living organism but are not composed of cells. They are made of only DNA, RNA or protein

(ii) **Eukaryotic Organelles:** Mitochondria and chloroplasts have their own DNA and can replicate independent of the cell's nucleus. This suggests they may have originated from **free-living prokaryotic cells.**

(iii) **Fung & Algae:** Some **organisms, such as certain fungi and algae,** have structures where multiple nucl coexist within a shared cytoplasmic mass. These structures **blur the boundaries** of individual cells a defined by traditional cell theory.

(iv) **Muscle Cells (Myocytes):** In vertebrates muscle cells can fuse to form **multinucleated fibres,** challengi the concept of a single cell as the basic unit in complex tissues.

Q.3 The table below compares the process of diffusion, facilitated diffusion and active transport. Fill in th blank ...s, using the words "YES" or "NO".

Ans.

Description	Process: Simple Diffusion	Facilitated Diffusion	Active Transport
Is ATP required?	No	No	Yes
Are carrier proteins involved?	No	Yes	No
Is direction of transport always from higher to lower concentration?	Yes	Yes	No

Q.4 Categorize the organelles as:
(i) Single membrane bounded (ii) Double membrane bounded (iii) Lacking any membrane

Ans.

Single Membranous Organelles	Double Membranous Organelles	Non-membranous Organelles
• Endoplasmic Reticulum (ER) • Golgi Apparatus • Lysosomes • Peroxisomes • Vacuoles (in plant and fungal cells)	• Mitochondria • Chloroplasts (only in plant cells and some protists) • Nucleus	• Ribosomes • Centrioles • Cytoskeleton (microtubules, microfilaments, intermediate filaments) • Nucleolus (though present inside the nucleus, it is not membrane-bound)

Q.5 State two functions of the proteins in the plasma membrane.

Ans. **Two Functions of the Proteins in the Plasma Membrane:**

- **Transport:** Many proteins play role in the selective transport of certain substances across the phospholipid bilayer, either acting as channels or active transport molecules.
- **Attachment:** Some proteins help in attachment of plasma membrane to cytoskeleton and external fibres.
- **Identification Marks:** Some proteins, on the exterior surface, attach with sugars and make identification marks.

Q.6 State two features that mitochondria have in common with prokaryotes.

Ans. **Two Common Features in Mitochondria and Prokaryotes:**

(I) DNA:
- Mitochondria contain their own circular DNA, similar to the DNA found in prokaryotes like bacteria. This supports the endosymbiotic theory.

(ii) 70S Ribosomes:
- Mitochondria possess 70S ribosomes, which are typical of prokaryotes, rather than the 80S ribosomes found in the eukaryotic cytoplasm.

Q.7 List three ways in which prokaryotic cells differ from eukaryotic cells.

Ans.

Prokaryotic Cell	Eukaryotic Cell
• **Cell Type:** Organisms made up of prokaryotic cells are called prokaryotes. • **Cell Size:** Average diameter of 1 – 10 μm. • **Form of Organism:** Uniceliular or filamentous. • **Nucleus:** No well defined nucleus is present. • **Genetic System:** DNA in suspended form. • Smaller ribosomes (70S). • Mitosis absent. • Cell divides by binary fission. • Cell wall made up of polysaccharide chains covalently bonded to amino acids forming peptidoglycan or murein. • Prokaryotic cell membrane **does not have cholesterol.** • **Examples:** Bacteria and cyanobacteria (Blue green algae).	• **Cell Type:** Organism made up of eukaryotic cells is called eukaryotes. • **Cell Size:** Mostly 10 – 100 μm in diameter. • **Form of Organism:** Unicellular, filamentous, simple multicellular, truly multicellular. • **Nucleus:** Well defined nucleus is present. • **Genetic System:** DNA with in nucleus. • Large ribosomes (80S). • Mitosis present. • Cell divides by mitosis & meiosis. • Cell wall mainly composed of cellulose (Plants) & of chitin (Fungi). • Eukaryotic cell membranes **have cholesterole.** • **Examples:** Animals, Plants, Fungi and Protists.

Q.8 List the structures and molecules, which can cross the nuclear envelope.

Ans. **Structure of Nuclear Envelope:**

- The nuclear envelope is a **double-layered** membrane that encloses the contents of the nucleus during most of the cell's lifecycle.

- **Perinuclear Space:** The space between the double layers is called the perinuclear space and is connected with the rough endoplasmic reticulum.
- During cell division, the nuclear envelope disintegrates, but reforms in the daughter cells.
- **Nuclear Lamina:** On the inner side of nuclear envelope, there is a protein lining, called nuclear lamina binds to chromatin to give it structural support.
- **Nuclear Pores:** The nuclear envelope has tiny holes known as nuclear pores.

Name of Molecules Cross the Nuclear Envelope:

- Here are molecules that can cross the nuclear envelope through nuclear pores:
- **mRNA (messenger RNA):** Carries genetic information from the nucleus to the cytoplasm for protein synthesis.
- **tRNA (transfer RNA):** Synthesized in the nucleus and exported to the cytoplasm to help in translation.
- **Ribosomal subunits:** Assembled in the nucleolus and exported to the cytoplasm for protein synthesis.
- **Proteins (e.g., histones, DNA/RNA polymerases):** Imported from the cytoplasm into the nucleus to perform various nuclear functions.

Q.9 Distinguish each of the following pairs.
a. exocytosis and endocytosis b. phagocytosis and pinocytosis c. peroxisome and glyoxysomes

Ans. a. exocytosis and endocytosis

Exocytosis	Endocytosis
• The outward transportation of materials from the cell then such process is called exocytosis e.g. transport of waste material or secretions across the membrane.	• The inward movement of the materials by infolding of cell membrane in the form of vacuole or vesicle is known as endocytosis.
• **Importance:** Exocytosis is essential for various bodily functions, such as neurotransmitter release at nerve synapses and secretion of substances like sweat from sweat glands.	• **Importance:** Cells such as amoebae or white blood cells extend portions of their cytoplasm, known as **pseudopodia** (or "false feet"), to enclose and ingest a target, subsequently forming an internal compartment called a **phagosome**.

b. phagocytosis and pinocytosis

Phagocytosis	Pinocytosis
• If the solid particles are taken in the cell such process or movement is known as phagocytosis.	• If the liquid material is ingested in the cell then the process is known as pinocytosis.

c. peroxisome and glyoxysomes

Peroxisome	Glyoxysomes
• **Occurrence:** Found in both animal and plant cells.	• **Occurrence:** Found only in plant cells, especially in fat-storing seeds.
• **Main Function:** Breakdown of fatty acids and detoxification (e.g., hydrogen peroxide via catalase).	• **Main Function:** Conversion of fatty acids into sugars via the glyoxylate cycle.
• **Key Enzymes:** Contain catalase and oxidases.	• **Key Enzymes:** Contain enzymes of the glyoxylate cycle (e.g., isocitrate lyase, malate synthase)
• **Role in Metabolism:** Involved in detoxification and lipid metabolism.	• **Role in Metabolism:** Important during seed germination to provide energy.

Q.10 What are the main functions of lysosomes?]

Ans. Main Functions of Lysosomes:

- **Break Cellular Wastes & Macromolecules:** They break down cellular waste products, fats, carbohydrates, proteins, and other macromolecules into simple compounds, which are then transferred back into the cytoplasm for making new materials.

- **Hydrolytic Enzymes:** Lysosomes have about **40 different hydrolytic** enzymes, all of which are manufactured in the endoplasmic reticulum and modified in the Golgi apparatus.
- **Protect From Damage:** The membrane covering of the lysosome protects the rest of the cell from the **harsh digestive** enzymes contained in the lysosomes, which would otherwise cause significant damage.

Q.11 Describe the role of the Golgi body in forming lysosomes.

Ans. Role of Golgi Bodies in Forming Lysosomes:

- **Step 1:** Synthesis of hydrolytic enzymes takes place in the rough endoplasmic reticulum (RER).
- **Step 2:** These enzymes are transported to the Golgi apparatus in vesicles.
- **Step 3:** Inside the Golgi, enzymes are modified, sorted, and packaged into small vesicles.
- **Step 4:** These vesicles bud off from the trans face of the Golgi and mature into primary lysosomes.
- Lysosomes are now ready to fuse with other vesicles to digest materials inside the cell.

Q.12 What are histones? Where are these found in eukaryotic cells?

Ans. Histones:

- Histones are positively charged proteins that help in the packaging and organization of DNA into structural units called nucleosomes in eukaryotic cells. They play a key role in gene regulation and chromatin structure.
- **Location in Eukaryotic Cells:** Histone proteins are found inside the nucleus, where they are closely associated with DNA to form chromatin.

Q.13 What do you mean by "stem cell"? What are the main usages of stem cells?

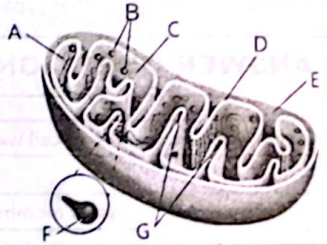
Ans. Stem Cells:

- The cells which have remarkable ability to develop into many different cell types in the body are called stem cells.

Uses of Stem Cells:

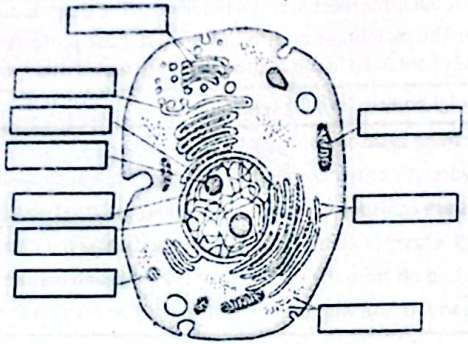
- **Regenerative Medicine:** Stem cells have the potential to repair or replace damaged tissues and organs. Therefore, they are used for treating conditions such as spinal cord injuries, type 1 diabetes, Parkinson's disease, and heart disease.
- **Drug Testing and Development:** By differentiating stem cells into specific cell types, researchers can create models of human diseases, allowing for more accurate testing of drug effects and reducing the reliance on animal models.
- **Personalized Medicine:** Stem cells can be derived from a patient's own cells, reducing the risk of immune rejection when used in treatments. This personalized approach can lead to more effective and safer therapies.

Q.14 The following diagram shows the structure of a mitochondrion. Name structures A to G.



Ans. A. DNA **B.** Ribosomes **C.** Matrix **D.** Inner Membrane
E. Inter Membrane space **F.** F_1 portion of F_0F_1–ATPase **G.** Cristae

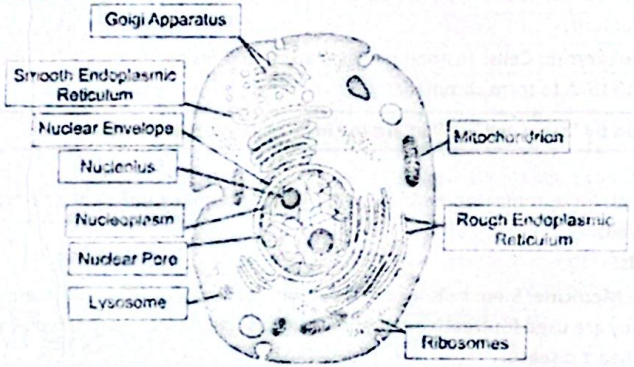
Q.15 The diagram below shows an electron micrograph of a cell.



a. Label the parts of the cell.

b. What evidence can be seen in the diagram that suggests that the cell is metabolically active and involved in secretion of enzymes?

Ans. a. Label the parts of the cell:



b.

(i) Abundant Rough Endoplasmic Reticulum (RER): The presence of well-developed RER indicates active protein synthesis, especially of enzymes, since ribosomes on RER translate mRNA into polypeptide chains for secretion.

(ii) Prominent Golgi Apparatus: The Golgi apparatus processes, packages, and modifies proteins into secretory vesicles. Cells secreting enzymes have a large, active Golgi complex to ensure efficient delivery of enzymes outside the cell.

(iii) High Mitochondrial Density: Secretion is an energy-intensive process. Numerous mitochondria indicate high ATP production, supporting energy demands for synthesis, packaging, and transport of enzymes.

Exercise — LONG ANSWER QUESTIONS — Section 03

Q.1 Write details of the structure and the chemical composition of cell walls of eukaryotes and prokaryotes.

Ans. **See Page No. (70)**

Q.2 Explain the chemical composition and the functions of plasma membrane.

Ans. **See Page No. (73)**

Q.3 Identify the role of glycolipids and glycoproteins as the cell surface markers.

Ans. *See Page No. (73)*

Q.4 Explain the structure, chemical composition and function of ribosomes.

Ans. **See Page No. (79)**

Q.5 Explain the structure, and functions of Golgi complex.

Ans. **See Page No. (82)**

Q.6 Describe the structure, chemical composition and function of chromosome.

Ans. **See Page No. (77)**

Q.7 Discuss nuclear envelope and nuclear pore complex in detail.

Ans. **See Page No. (76)**

Q.8 Explain how Golgi apparatus is involved in making cell secretions.

Ans. Role of Golgi Apparatus in Making Cell Secretions:

- **Receiving Proteins:** Proteins and lipids synthesized in the endoplasmic reticulum (ER) are sent to the Golgi apparatus in vesicles.
- **Modification:** Within the Golgi, these molecules are chemically modified (e.g., glycosylation, phosphorylation) for proper functioning.
- **Sorting and Packaging:** The modified products are sorted and packed into new vesicles according to their destination.
- **Vesicle Transport:** Secretory vesicles bud off from the trans face of the Golgi.
- **Exocytosis:** These vesicles fuse with the plasma membrane and release their contents outside the cell as secretions.
- This is how the Golgi apparatus plays a central role in the processing and secretion of cellular products.

Q.9 Describe the structure and functions of smooth and rough endoplasmic reticulum.

Ans. **See Page No. (78)**

Q.10 Explain the role of lysosomes and peroxisomes in regulating the amounts of cellular contents.

Ans. Role of Lysosomes and Peroxisomes in Regulating Cellular Contents:

i. Lysosomes – Intracellular Digestion:

- Contain hydrolytic enzymes that break down worn-out organelles, proteins, and other macromolecules.
- Help regulate cellular contents by removing damaged or excess components.
- Play a key role in autophagy, recycling useful cell materials.
- Prevent accumulation of waste by digesting harmful substances.

ii. Peroxisomes – Detoxification and Lipid Regulation:

- Contain enzymes like oxidases and catalase that break down fatty acids and toxic substances (e.g., hydrogen peroxide).
- Help regulate cell metabolism by controlling lipid levels and oxidative stress.
- Convert long-chain fatty acids into smaller molecules for energy or further processing.
- Protect cells by neutralizing reactive oxygen species that could damage cellular structures.

- Together, lysosomes and peroxisomes maintain cellular balance, prevent damage, and support cell health by regulating the quality and quantity of cellular components.

Q.11 Describe the structures of the three fibres that make the cytoskeleton.

Ans. **See Page No. (86)**

Q.12 Describe the formation and functions of lysosomes.

Ans. **See Page No. (83)**

Q.13 Compare mitochondria and chloroplasts as the organelles that are involved in cellular energetics.

Ans. Comparison of Mitochondria and Chloroplasts in Cellular Energetics:

i. **Type of Energy Conversion:**
   - **Mitochondria:** Convert chemical energy from glucose into ATP through cellular respiration.
   - **Chloroplasts:** Convert light energy into chemical energy (glucose) through photosynthesis.

ii. **Energy Source:**
   - **Mitochondria:** Use glucose and oxygen as energy sources.
   - **Chloroplasts:** Use sunlight, water, and carbon dioxide for energy production.

iii. **Main Function in Energetics:**
   - **Mitochondria:** Serve as the powerhouse of the cell, providing usable energy (ATP).
   - **Chloroplasts:** Serve as the site of energy capture, storing energy in glucose.

iv. **Presence in Cells:**
   - **Mitochondria:** Found in all eukaryotic cells (plants, animals, fungi, etc.).
   - **Chloroplasts:** Found only in plant cells and some protists.

v. **ATP Production:**
   - **Mitochondria:** Directly produce large amounts of ATP.
   - **Chloroplasts:** Produce ATP during photosynthesis, but it is mainly used within the chloroplast to make glucose.

- Both organelles are double-membraned and contain their own DNA, reflecting their essential roles in cellular energy management.

Q.14 Describe the basic structure of a mitochondrion, from outside inward.

Ans. **See Page No. (80)**

Q.15 Describe the pathway of protein signal and steroid signal from outside of a cell to inside.

Ans. **See Page No. (89)**

Q.16 Categorize and explain different types of stem cells.

Ans. **See Page No. (95)**

Q.17 What are the advantages and disadvantages of using induced Pluripotent Stem Cells?

Ans. **See Page No. (95)**

Exercise — INQUISITIVE ANSWER QUESTIONS

Q.1 If a researcher observes that a certain cell type has an exceptionally large Golgi apparatus, what can be inferred about the function of this cell?

Ans. (i) Active in Protein Secretion:
   - A large Golgi apparatus suggests the cell is producing and secreting large amounts of proteins.
   - Common in cells like plasma cells (antibody production) and pancreatic cells (digestive enzymes).

(ii) Intensive Processing and Packaging:
   - The Golgi modifies proteins and lipids (e.g., glycosylation, phosphorylation).
   - Its enlargement indicates heavy traffic of materials needing sorting and packaging.

(iii) Hormone or Mucus Production:
   - Seen in cells like endocrine cells (hormones) and goblet cells (mucus).
   - These secretory cells rely on the Golgi for exporting complex substances.

Q.2 If a signaling molecule is lipid-soluble, like a steroid hormone, what is the most likely mechanism for its action within the target cell?

Ans. If a signaling molecule is lipid-soluble like a steroid hormone, the most likely mechanism for its action within the target cell involves:
- Diffusion through the plasma membrane due to its lipid-soluble nature.
- Binding to intracellular receptors located in the cytoplasm or nucleus.
- The hormone-receptor complex then enters the nucleus (if not already there).
- It binds to specific DNA sequences, acting as a transcription factor.
- This leads to activation or repression of specific genes, altering protein synthesis.
- The resulting proteins change the cell's structure or function in response to the hormone.

Q.3 Why do we categorize endocytosis and exocytosis in active transport?

Ans. Endocytosis and exocytosis are categorized as active transport for the following reasons:
- Both processes require energy in the form of ATP to move large molecules across the cell membrane.
- They involve membrane remodeling, such as vesicle formation (in endocytosis) and fusion (in exocytosis).
- Materials are moved against concentration gradients, which passive transport cannot achieve.
- Endocytosis helps in importing large particles (e.g., nutrients, pathogens) into the cell.
- Exocytosis allows cells to export substances like hormones or enzymes.
- Due to their energy-dependent nature, they are classified under active transport mechanisms.

Q.4 Justify why the membrane may be described as fluid.

Ans. The membrane is named "fluid" because of the following key reasons:
- Phospholipids are not fixed; they constantly move sideways within the layer, creating a fluid-like motion.
- Proteins float and move within the lipid bilayer, similar to objects drifting in a fluid.
- The membrane behaves like a viscous liquid, allowing components to rearrange and adapt easily.
- This constant lateral movement gives the membrane a fluid consistency, rather than being static or solid.

ADDITIONAL MCQs

Q.1 Which property of life is demonstrated when an amoeba divides into two daughter cells?
A) Respiration B) Growth C) Reproduction D) Nutrition

Q.2 What observation would most directly support cell theory?
A) Viruses reproducing B) Cells forming spontaneously
C) All living things made of cells D) Plants using sunlight for energy

Q.3 Which experiment supports the idea that cells arise from preexisting cells?
A) Pasteur's swan-neck flask experiment B) Griffith's transformation experiment
C) Mendel's hybrid plant crosses D) Miller-Urey's early Earth simulation

Q.4 Why are electron microscopes preferred for viewing subcellular structures?
A) Use natural light B) Allow color imaging C) Offer higher resolution D) Require staining only

Q.5 What distinguishes plant cell ultrastructure from animal cells?
A) Presence of centrioles B) Presence of cell wall and chloroplasts
C) Absence of mitochondria D) Absence of Golgi apparatus

Q.6 What is a defining ultrastructural feature of animal cells?
A) Large central vacuole B) Chloroplast C) Centrioles D) Cell wall

Q.7 Which function is associated with lysosomes?
A) Energy production B) Protein synthesis
C) Digestion of cellular waste D) Lipid storage

Q.8 Which structure is found in eukaryotic but not in prokaryotic cells?
A) Plasma membrane B) Cytoplasm C) Nucleus D) Ribosomes

Q.9 Why are prokaryotes more efficient in reproduction?
A) More organelles B) Larger in size C) Simpler cell structure D) Eukaryotic DNA

Q.10 What technique is most suitable to study membrane proteins?
A) Electron microscopy B) Protein electrophoresis C) Cell fractionation D) Gel chromatography

Q.11 Which molecule is most likely to initiate cell signaling?
A) Enzyme B) Hormone C) Organelle D) Water

Q.12 Which structure is key in signal reception?
A) Ribosome B) Receptor protein C) Mitochondria D) Vacuole

Q.13 Which signal enters the cell directly?
A) Steroid hormone B) Peptide hormone C) Neurotransmitter D) Insulin

Q.14 Which transport method requires energy?
A) Simple diffusion B) Facilitated diffusion C) Osmosis D) Active transport

Q.15 In facilitated diffusion, molecules move via:
A) Lipid bilayer only B) Channel or carrier proteins C) Vesicles D) Golgi bodies

Q.16 Exocytosis involves:
A) Engulfing solid particles B) Releasing contents outside the cell
C) Pinching of Golgi bodies D) Mitochondrial division

Q.17 What differentiates facilitated diffusion from simple diffusion?
A) Needs membrane proteins B) Requires energy
C) Occurs in solids D) Only in prokaryotes

Q.18 Which molecule is most likely to use facilitated diffusion?
A) Oxygen B) CO_2 C) Glucose D) Urea

Q.19 One advantage of using stem cells in therapy is:
A) Inability to form tissues B) Rejection risk is high
C) Can regenerate damaged tissues D) Immediate death of cells

Q.20 Which type of stem cell can become any cell type in the body?
A) Multipotent B) Unipotent C) Totipotent D) Pluripotent

Q.21 What type of stem cell can only form one type of cell?
A) Pluripotent B) Multipotent C) Unipotent D) Embryonic

Q.22 What is a major risk of using iPSCs?
A) Cancer formation B) No differentiation C) Viral infection D) Rapid aging

ANSWER KEY

1. C)	2. C)	3. A)	4. C)	5. B)	6. C)	7. C)	8. C)	9. C)	10. A)	11. B)	12. B)
13. A)	14. D)	15. B)	16. B)	17. A)	18. C)	19. C)	20. D)	21. C)	22. A)		

ADDITIONAL SHORT ANSWER QUESTIONS

Q.1 What are the three main points of modern cell theory?

Ans. Three Main Points of Modern cell Theory:
- All living things are made of cells.
- Cells are the basic units of structure and function.
- All cells come from pre-existing cells.

Q.2 What is the main principle behind how a light microscope works?

Ans.
- **Light Source:** It uses visible light to illuminate the specimen.

- **Lenses:** Glass lenses bend (refract) the light to magnify the image.
- **Magnification:** It can magnify objects up to around 1000 times.
- **Usage:** Commonly used to observe cells, tissues, and microorganisms.
- **Limitation:** It cannot show very small details like viruses or DNA strands.

Q.3 Explain the main features of the Fluid Mosaic Model of the plasma membrane.

Ans. Main Features of the Fluid Mosaic Model:
- The plasma membrane is made of a phospholipid bilayer with embedded proteins.
- 'Fluid' means components can move laterally within the layer.
- 'Mosaic' refers to the patchwork of proteins scattered in the lipid layer.
- This model explains membrane flexibility, self-repair, and selective transport.

Q.4 Describe three major functions of membrane proteins in the plasma membrane.

Ans. Three Major Functions of Membrane Proteins:
- **Transport:** Channel and carrier proteins move ions and molecules across the membrane.
- **Receptors:** Bind specific signaling molecules (e.g., hormones) to trigger cellular responses.
- **Enzymatic Activity:** Some proteins catalyze reactions right at the membrane surface.

Q.5 How are iPSCs produced in the lab?

Ans.
- **Source:** iPSCs are made by reprogramming adult cells, like skin or blood cells.
- **Method:** Genes like Oct4, Sox2, Klf4, and c-Myc are introduced to the cells.
- **Pluripotency:** They gain the ability to become any cell type, like ESCs.
- **Advantages:** iPSCs avoid ethical concerns linked to embryo use.
- **Applications:** Useful for research, disease modeling, and personalized medicine.

Q.6 Describe the structure and function of the nucleolus.

Ans. Structure and Function of the Nucleolus:
- The nucleolus is a dense region inside the nucleus without a membrane.
- **It has two main regions:** the fibrillar center (site of rRNA synthesis) and granular component (ribosome assembly).
- It produces rRNA and assembles ribosomal subunits.

Q.7 Define the endoplasmic reticulum and explain its basic structure.

Ans. Endoplasmic Reticulum:
- The endoplasmic reticulum (ER) is a network of membrane-bound tubules and sacs called cisternae.
- It is continuous with the nuclear envelope.
- The inner fluid-filled region is known as the cisternal space.
- ER exists in two forms: rough and smooth, performing distinct functions.

Q.8 Role of Stroma in Chloroplast Function.

Ans. Role of Stroma in Chloroplast:
- The stroma is the fluid-filled space surrounding thylakoids. It hosts the Calvin cycle, where CO_2 is fixed into glucose using ATP and NADPH produced in the light-dependent reactions.
- Enzymes like RuBisCO and components for starch synthesis are also located here.

Q.9 Why do plant cells have more active Golgi bodies during cell wall formation?

Ans. Active Golgi Bodies During Cell Wall Formation
- **Production of Polysaccharides:** Golgi bodies synthesize and package polysaccharides like pectins and hemicelluloses, essential components of the plant cell wall.
- **Vesicle Transport:** They form vesicles that transport these cell wall materials to the plasma membrane.

- **Cell Wall Assembly:** The delivered materials are secreted outside the cell, contributing to the building and strengthening of the cell wall.
- **Increased Demand:** During cell wall formation, the need for these substances rises, making Golgi bodies more active.

Q.10 How do lysosomes help maintain cellular homeostasis?

Ans. Role of Lysosomes in Maintaining Cellular Homeostasis:

- **Waste Breakdown:** Lysosomes digest and break down unwanted cellular debris and damaged organelles.
- **Recycling Materials:** They recycle useful molecules back into the cell for reuse.
- **Pathogen Defense:** Lysosomes destroy invading pathogens like bacteria.
- **Regulating Cellular Environment:** By controlling the removal of waste and recycling, lysosomes help maintain the cell's internal balance and health.

Q.11 Why are glyoxysomes absent in mature plant cells?

Ans. Absence of Glyoxysomes in Mature Plant Cells:

- **Role in Seed Germination:** Glyoxysomes are primarily active in young, germinating seeds to convert stored fats into sugars.
- **Function Completion:** Once the seedling develops and starts photosynthesis, the need for glyoxysomes decreases.
- **Replacement by Other Organelles:** Mature cells rely more on chloroplasts and mitochondria for energy, so glyoxysomes disappear.

Q.12 Why are embryonic stem cells considered pluripotent?

Ans. Why Embryonic Stem Cells Are Considered Pluripotent:

- **Ability to Differentiate:** Embryonic stem cells can develop into almost any cell type in the body.
- **Origin from Inner Cell Mass:** They come from the inner cell mass of the blastocyst, which gives rise to all tissues.
- **Versatility:** Unlike multipotent cells, they are not limited to a few cell types.
- **Pluripotency Definition:** Their capacity to form cells from all three germ layers (ectoderm, mesoderm, endoderm) makes them pluripotent.

SELF-ASSESSMENT Chapter # 03

Total Mark: 30

Q.1 Encircle the correct option. **(1 x 6 = 06)**

i. Which of the following is not an accurate description of a chromosome?
(a) It is a coloured body localized in the nucleus
(b) It is a protein and nucleic acid complex
(c) It is the cellular structure that contains the genetic material
(d) In eukaryotes, it is composed of many DNA molecules attached end to end

ii. The rough endoplasmic reticulum is:
(a) An intracellular single-membrane system to which ribosomes are attached
(b) An intracellular membrane that is studded with microtubular structures
(c) A membranous structure found within mitochondria
(d) Only found in prokaryotic cells

iii. Which of the following statements does not apply to the nuclear envelope?
(a) It is a double membrane
(b) It is continuous with the endoplasmic reticulum
(c) It has pores through which material enters and leaves
(d) It has infoldings to form cristae

iv. All peroxisomes carry out this function:
(a) Break down fats and amino acids into smaller molecules that can be used for energy production by mitochondria
(b) Digest macromolecules using the hydrolytic enzymes they contain
(c) Synthesize membrane components such as fatty acids and phospholipids
(d) Control the flow of ions into and out of the cell

v. Which of the following does not apply to chloroplasts?
(a) They contain chlorophyll and the enzymes required for photosynthesis.
(b) They contain an internal membrane system consisting of thylakoids.
(c) They synthesize ATP.
(d) They are bounded by two membranes, the inner of which is folded into the cristae.

vi. How does the process of facilitated diffusion differ from active transport?
(a) Facilitated diffusion requires energy, active transport does not
(b) Facilitated diffusion does not require energy, active transport does
(c) Both processes require energy
(d) Both processes do not require energy

Q.2 Write short answers of the following questions. **(2 x 8 = 16)**

i. State the cell theory. How we can validate it? What are the exceptions to cell theory?
ii. Categorize the organelles as (i) single membrane bounded, (ii) double membrane bounded and (iii) lacking any membrane.
iii. State two features that mitochondria have in common with prokaryotes.
iv. List the structures and molecules, which can cross the nuclear envelope.
v. Describe the role of the Golgi body in forming lysosomes.
vi. What do you mean by "stem cell"? What are the main usages of stem cells?
vii. Role of Stroma in Chloroplast Function.
viii. Why are embryonic stem cells considered pluripotent?

Q.3 Extensive Questions. **(4 x 2 = 8)**

(a) Discuss nuclear envelope and nuclear pore complex in detail.
(b) Describe the pathway of protein signal and steroid signal from outside of a cell to inside.