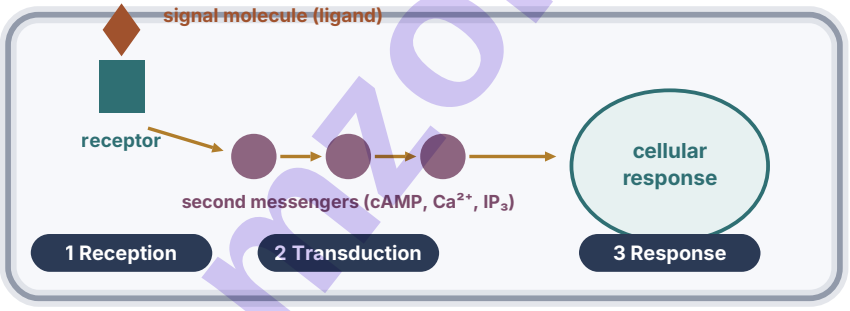
BIOLOGY · CLASS 11 · NEW SYLLABUS

UNIT 3

Cells and Subcellular Organelles

Complete Study Booklet



Long Questions | Short Questions | MCQs | Solved Exercise

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PART A

Long Questions

Cells — the Basic Unit of Life

Q1 **What is cell? Explain seven basic properties of cell and living organism.**

Cells are the basic unit of life, making every living organism. Some organisms are unicellular like amoebas and bacteria, and some are multicellular such as plants and animals. All living organisms show the seven basic properties, i.e. movement, respiration, homeostasis, growth, reproduction, excretion and nutrition. These properties actually define living organisms. Cells perform all the fundamental activities that characterize living organisms.

- **Movement:** cells can move. For example, 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.
- **Nutrition:** cells obtain nutrients from their environment to produce energy, build cellular structures and drive biochemical reactions.
- **Respiration:** cells generate energy through respiration. This process breaks glucose to release ATP, the energy currency that powers cellular activities.
- **Excretion:** cells remove waste products through diffusion and active transport, preventing toxic build-up.
- **Homeostasis:** cells maintain a stable internal environment by regulating the movement of substances across their membranes.
- **Growth:** cells grow by taking in nutrients and converting them into cellular components.
- **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

Q2 **Give detail of development of cell theory.**

History: the contribution of different scientists in the formulation of cell theory is as follows:

- **Robert Hooke:** in **1665**, English scientist Robert Hooke examined a thin slice of cork of oak tree under a microscope. He observed that the cork was made of “many little boxes”. He also examined pieces of stem and root of oak tree and found that these were also made of similar little boxes. He concluded that the parts of plants were made of compartments, which he named **“cellulae”**.

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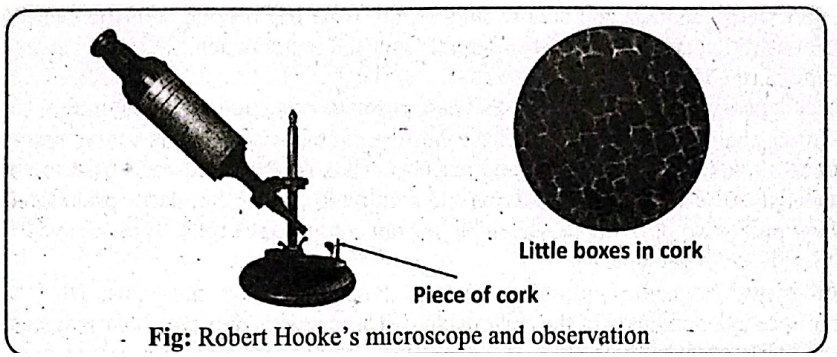


Fig: Robert Hooke's microscope and observation

- **Anton van Leeuwenhoek:** in **1673**, the Dutch scientist made a better microscope and observed living cells in pond water. He called these cells **animalcules**.
- **Jean Baptiste de-Lamarck:** in **1809**, the French biologist also observed cells when he examined the parts of animals and plants under microscope.
- **Robert Brown:** in **1831** the British botanist discovered the **nucleus** in the cell.
- **Matthias Schleiden:** in **1838**, the German botanist observed many parts of plants under microscope and concluded that all plants are composed of cells.
- **Theodor Schwann:** the German zoologist concluded the same for animals.
- **Rudolf Virchow:** in **1855**, the German physician Rudolf Virchow (1821–1902) observed that all cells come from other cells.
- **Louis Pasteur:** in **1862**, Louis Pasteur provided the experimental proof of this idea. These observations were combined to form a basic theory about cells, called the **cell theory**.

*The notes give 1885 for Virchow; his statement that all cells come from pre-existing cells (omnis cellula e cellula) was published in **1855** (corrected).*

Salient features of cell theory

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

Q3 **Explain about validation of cell theory. Also give exceptions to cell theory.**

Validation of cell theory

Cell theory can be validated to prove it correct through several observations and experiments:

- By using light microscopes and electron microscopes, scientists visualize (see) cell structures and find tangible (clear) evidence that cells are indeed the structural units of all living organisms.
- Through techniques like live-cell imaging and genetic studies, scientists can observe how cells replicate and give rise to new cells. These techniques validate the principle that all cells originate from pre-existing cells.
- Techniques like DNA sequencing reveal that cells share common genetic material and metabolic pathways, making the concept strong that the cell is the fundamental unit of life.
- Experiments such as cell-culture studies and tissue engineering validate cell theory by demonstrating cellular growth, differentiation and reproduction.

Exceptions to cell theory

- **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 organisms but are not composed of cells; they are made of only DNA, RNA or proteins.

- 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.
- Some organisms, such as certain **fungi and algae**, have structures where multiple nuclei coexist within the same cytoplasmic mass. These structures create confusion about the boundaries of individual cells as defined by traditional cell theory.
- **Muscle cells** (myocytes) in vertebrates can fuse to form multinucleated fibres, challenging the concept of a single cell as the basic unit in complex tissues.

Microscopy

Q4 **What is microscopy? Write its significance and compare light microscopy with electron microscopy.**

Microscopy is the technique of using microscopes to observe and study objects that are too small to be seen with the naked eye. Microscopes use lenses and light or electron beams to magnify and make specimens bright and clear. The significance of microscopy is that further studies of the internal structure of cells depend upon it.

A. Light microscopy

(i) Working principle: in the light microscope, light is used to make the image of the object. Light passes through the object and then through two glass lenses. One lens produces an enlarged image of the object and the second lens magnifies the image more. After passing through the object and lenses, the light forms an enlarged, clear image in the viewer's eye.

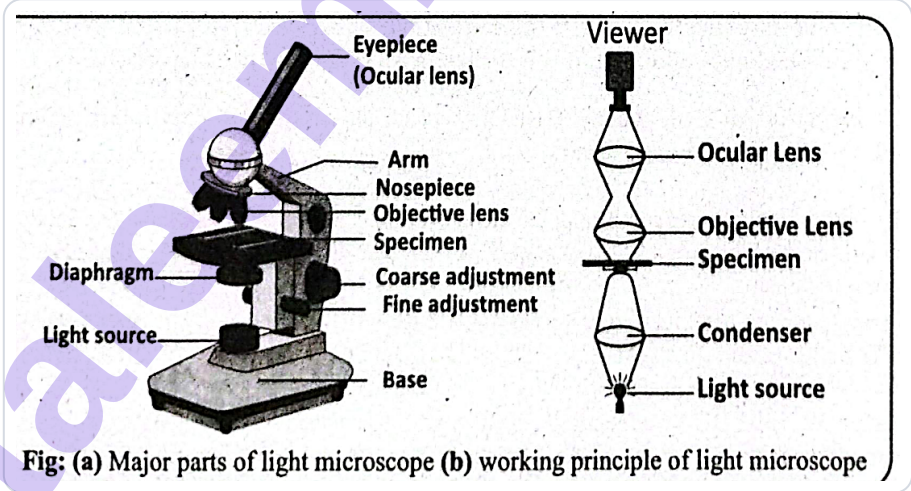


Fig: (a) Major parts of light microscope (b) working principle of light microscope

(a) Major parts of light microscope (b) working principle of light microscope

(ii) Magnification and resolution: the magnification of a light microscope is **1500X**, i.e. it can magnify objects about 1500 times. Its resolving power is **0.2 micrometre** (µm) (1 µm = 1/1000 mm). In other words, the light microscope cannot distinguish objects smaller than 0.2 µm.

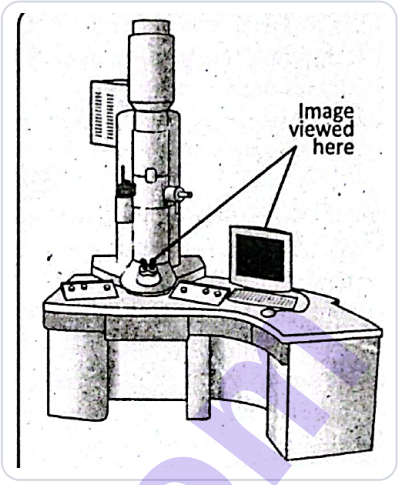
(iii) Advantage: light microscopes are advantageous for viewing **living organisms**, but since individual cells are generally transparent, their components are not distinguishable unless they are coloured with special stains (coloured chemicals). Staining, however, usually kills the cells.

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B. Electron microscopy

(i) Working principle: a beam of electrons passes through the object. Magnetic lenses focus the electron beam on a screen or photographic film and make a much enlarged image.

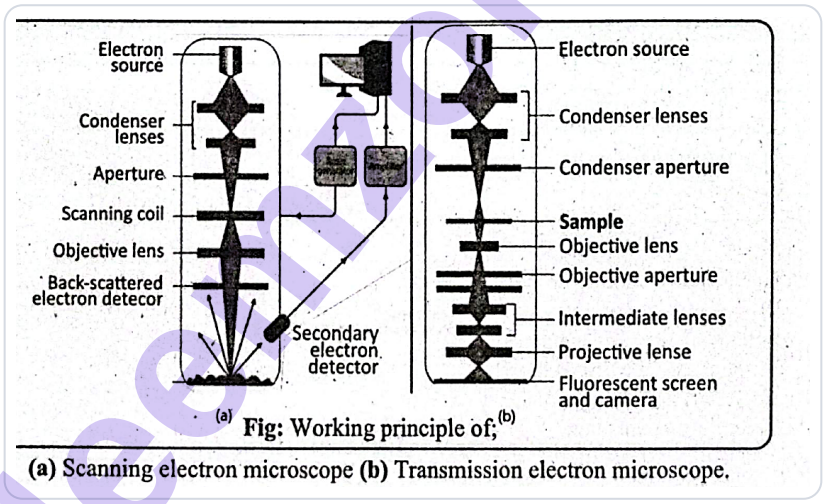
(ii) Resolving power: much greater than the light microscope. It can clearly show objects as small as **0.2 nanometre** (nm) (1 nm = 1/1,000,000 mm). However, the electron microscope cannot be used for viewing living material because of the methods needed to prepare the specimens.



Electron microscope

(iii) Types of electron microscope

a. **Transmission Electron Microscope (TEM)** is used to view the internal structure of cells. TEM transmits a beam of electrons through a very thin specimen. It can magnify objects up to **250,000 times**.
b. **Scanning Electron Microscope (SEM)** is used to study the details of surfaces of cells or other objects. The surfaces are coated with metal; when the electron beam hits the metal it is reflected and makes an enlarged image. SEMs can magnify objects up to **100,000 times**.



Working principle of (a) SEM and (b) TEM

Q5 **Give various differences between electron microscope and light microscope.**

Light microscope	Electron microscope
Uses light (approx. 400–700 nm) as an illuminating source.	Uses electron beams (approx. 1 nm) as an illuminating source.
Lower magnification (usually 500X to 1500X) than an electron microscope.	Higher magnification (direct magnification is 16000X and photographic magnification is 1000000X).

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Low resolution (maybe 0.2 µm); both live and dead specimens can be seen.	High resolution (maybe 0.2 nm); only dead and dried specimens can be seen.
Specimen preparation takes about a few minutes or an hour.	Specimen preparation takes several days.
The image is seen through the ocular lens; no screen needed.	The image is received on a zinc sulphate fluorescent screen.

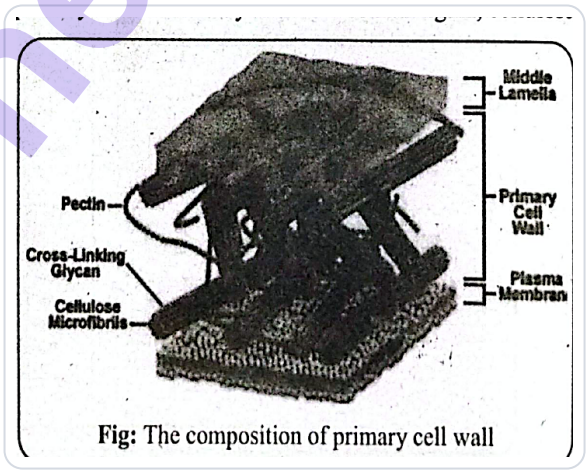
Structure of Cell

Q6 Write note on structure and function of cell wall.

A. Structure

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

- **Primary wall:** the actual cell wall. 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.
- **Middle lamella:** a gelatinous layer that separates and holds the primary walls of neighbouring cells. It is laid first, formed from the cell plate during cytokinesis, and the primary wall is then expanded inside it. It contains **magnesium and calcium pectates** (salts of pectic acid).
- **Secondary wall:** found in some plant cells after maturation; made between the protoplast and primary wall. It contains **lignin**, cellulose and hemicellulose. Due to lignin it is more rigid than the primary wall.



Composition of primary cell wall

B. Functions

- 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.
- Prevent expansion when water enters the cell.
- Protect against pathogens and the environment and are a store of carbohydrates for the plant.

Q7 What are plasmodesmata and write their function?

Plasmodesmata (singular, plasmodesma) are small channels that directly connect the cytoplasm of neighbouring plant cells to each other. Plasmodesmata penetrate both the primary and

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secondary cell walls. They allow certain molecules to pass directly from one cell to another, so they are important in **cellular communication**.

Plasmodesmata are formed during cell division when parts of the endoplasmic reticulum of the parent cell get trapped in the new cell wall.

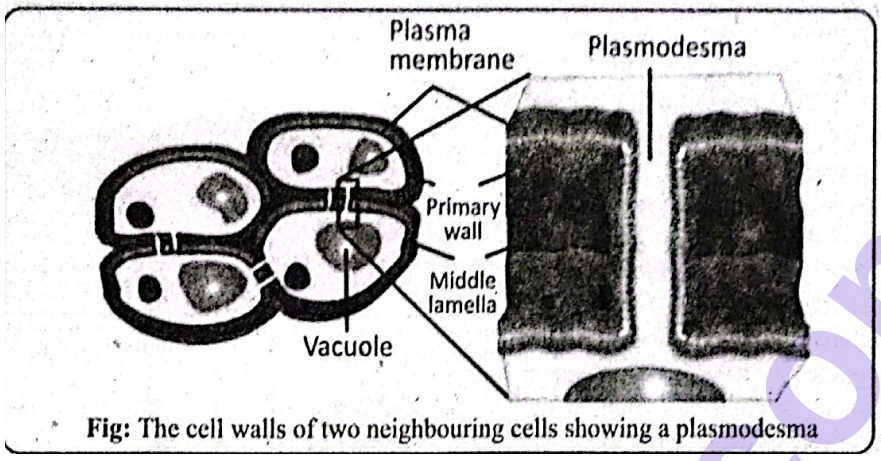


Fig: The cell walls of two neighbouring cells showing a plasmodesma

The cell walls of two neighbouring cells showing a plasmodesma

Q8 **Compare cell wall composition of algae, fungi, prokaryotes and archaebacteria.**

Organism	Cell wall composition
Algae	Cellulose and a variety of glycoproteins
Fungi	Chitin — the same carbohydrate that gives strength to the exoskeleton of insects
Prokaryotes (bacteria and cyanobacteria)	Peptidoglycan — a single large polymer of amino acids and sugar
Archaebacteria	Different polysaccharides and proteins, with no peptidoglycan

Plasma Membrane

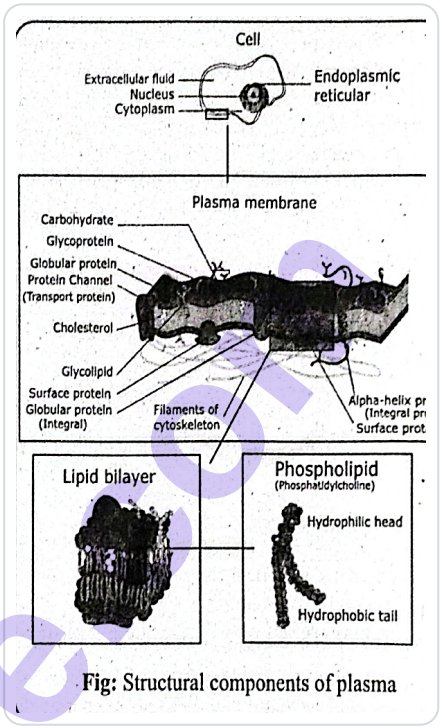
Q9 **Explain structure of plasma membrane.**

The plasma membrane is a basic component of prokaryotic as well as eukaryotic cells. It encloses the internal contents of the cell and acts as a semi-porous barrier. It controls the exchange of materials between cell and external environment.

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Fluid mosaic model: a widely accepted concept that describes the dynamic nature of the plasma membrane. It was proposed by two American biologists **S.J. Singer and Garth Nicolson in 1972**.

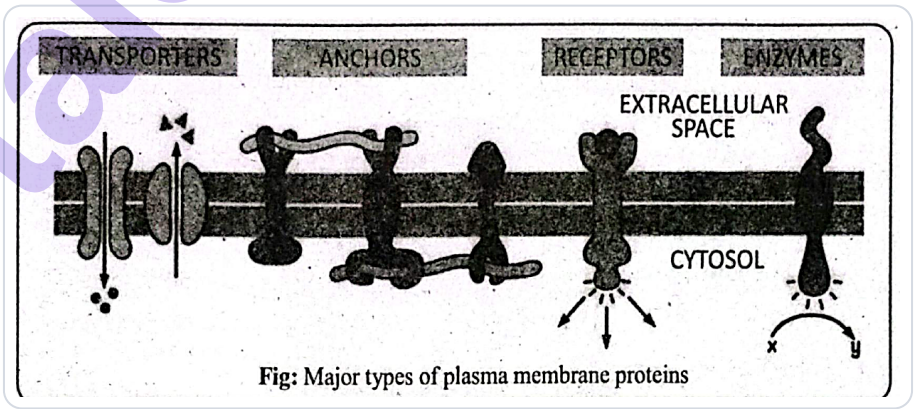
1. **Lipid bilayer:** according to the fluid mosaic model, the basic foundation of the plasma membrane is a lipid bilayer made of **phospholipids**. A collection of proteins float within the lipid bilayer.
2. **Phospholipids:** each has a phosphate group at one end. Phospholipids are **hydrophilic** ("water-loving") at their phosphate ends and **hydrophobic** ("water-fearing") along their tail regions containing C–H chains. In the bilayer, the hydrophobic tails are oriented inwards and the hydrophilic phosphate groups are aligned outwards, toward the cytoplasm or the extracellular environment.
3. **Cholesterol:** in eukaryotes, plasma membranes have cholesterol molecules wedged into the bilayer. They keep the fluidity of the membrane at low temperatures.
4. **Proteins:** many proteins float within the phospholipid bilayer; some simply adhere to the surfaces of the bilayer. Their positioning is related to the organization of the cytoskeleton.



Structural components of plasma membrane

Types and functions of membrane proteins

- **Selective transport:** many proteins transport certain substances across the bilayer, acting as channels or in active transport.
- **Attachment:** some help in attachment of the membrane to the cytoskeleton and external fibres.
- **Identification marks:** some proteins on the exterior surface attach with sugars and make identification marks.
- **Receptors:** others bind messenger molecules (e.g. hormones) and transmit signals to the interior of the cell.
- Some proteins also show **enzymatic** activity, catalysing various reactions related to the membrane.



Major types of plasma membrane proteins

5. Glycocalyx: the outside surface of the plasma membrane has chains of sugars bonded to proteins and lipids. A protein with attached sugar is a **glycoprotein**; a lipid with attached sugar is

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a **glycolipid**. They vary from species to species, individual to individual, and even from one cell type to another. Collectively called **glycocalyx**, they function as cell identification marks recognized by other cells.

Q10 **Explain functions of plasma membrane.**

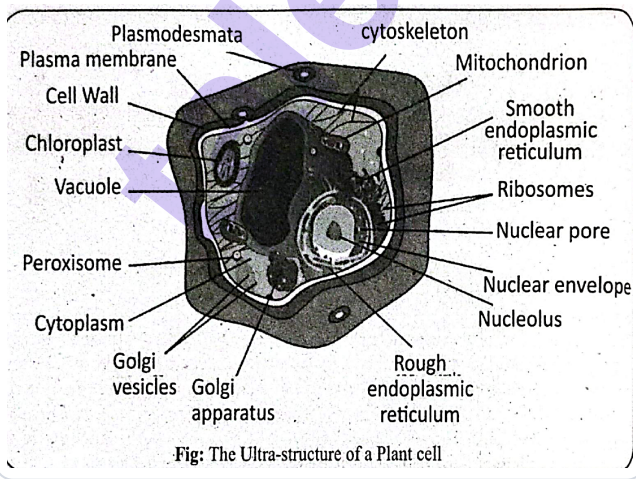
i. Plasma membranes serve as **semi-porous barriers** to the outside environment.
ii. The membrane acts as a **boundary**, holding the cell constituents together.
iii. It is **permeable to specific molecules**; it allows nutrients and other essential elements to enter the cell and waste materials to leave.
iv. Small molecules such as oxygen, carbon dioxide and water pass freely, but the passage of larger molecules such as amino acids and sugars is carefully regulated.
v. Eukaryotic cells also have membranes around some interior organelles; these too regulate the flow of materials into and out of organelles.

Cytoplasm and Organelles

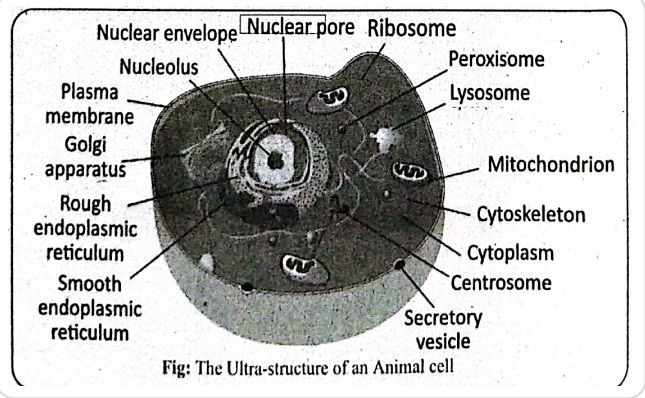
Q11 **Write note on cytoplasm and organelles.**

Structure of cytoplasm

i. The cytoplasm is a semi-viscous and semi-transparent substance.
ii. In eukaryotic cells, it is present between the plasma membrane and nuclear envelope.
iii. In prokaryotic cells, it covers all the space beneath the plasma membrane.
iv. It consists of an aqueous ground substance, known as **cytosol**, which contains a variety of organelles and other inclusions.
v. Cytosol contains water in which many organic (proteins, carbohydrates, lipids) and inorganic salts are completely or partially dissolved.
vi. The cytoplasm contains discrete structures specific for various cellular functions, called **cell organelles**; they are generally enclosed by membrane, except a few such as ribosomes.



Ultra-structure of a plant cell



Ultra-structure of an animal cell

Functions of cytoplasm

i. Provides space for proper functioning of the organelles.
ii. Acts as the site for various biochemical (metabolic) reactions, e.g. **glycolysis** (breakdown of glucose during aerobic respiration).

Q12 **Mention various techniques to study the structure of plasma membrane.**

- **Transmission Electron Microscopy** reveals detailed structures of the lipid bilayer and associated proteins.
- **Scanning Electron Microscopy** is useful for examining the surface topology of cells and membranes.
- **Confocal Microscopy** uses laser scanning and fluorescence to create sharp, detailed images of the cell membrane.
- **Total Internal Reflection Fluorescence Microscopy** gives high-resolution images of the membrane and its interactions with the cytoskeleton and other cellular components.
- **Atomic Force Microscopy** provides topographical images of the cell membrane at high resolution.
- **X-ray Crystallography** determines the atomic structure of membrane proteins.
- **Lipidomics** — comprehensive analysis of lipids in the membrane using techniques like mass spectrometry.
- **Fluorescence Recovery After Photobleaching** studies the mobility and dynamics of membrane proteins and lipids: a fluorescently labelled region is bleached with a laser and the recovery of fluorescence is observed as unbleached molecules move in.

Nucleus

Q13 **Explain structure and function of nucleus.**

1. Location: a prominent nucleus is present in all eukaryotic cells (at centre in animal cells, pushed to the side in plant cells). The spherical nucleus typically occupies about **10 percent** of a eukaryotic cell's volume.

2. Functions: (i) it serves as the information-processing and administrative centre of the cell. (ii) It stores the cell's hereditary material (DNA) and coordinates the cell's activities, e.g. growth, protein synthesis and cell division.

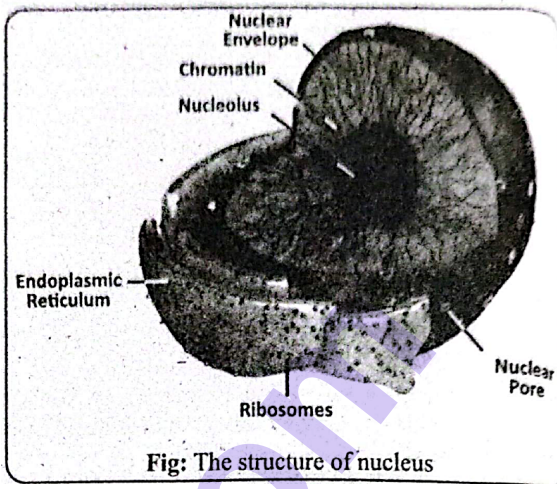
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3. Structure of nucleus

a. Nucleoplasm: the semifluid matrix inside the nucleus. Within it, most nuclear material consists of **chromatin**, which organizes to form chromosomes during cell division. The nucleus also contains one or more nucleoli, which synthesize ribosomes.

b. Nuclear envelope: a double-layered membrane that encloses the contents of the nucleus during most of the cell's lifecycle. The space between the layers is the **perinuclear space**, connected with the rough endoplasmic reticulum. During cell division the envelope disintegrates but reforms in the daughter cells.

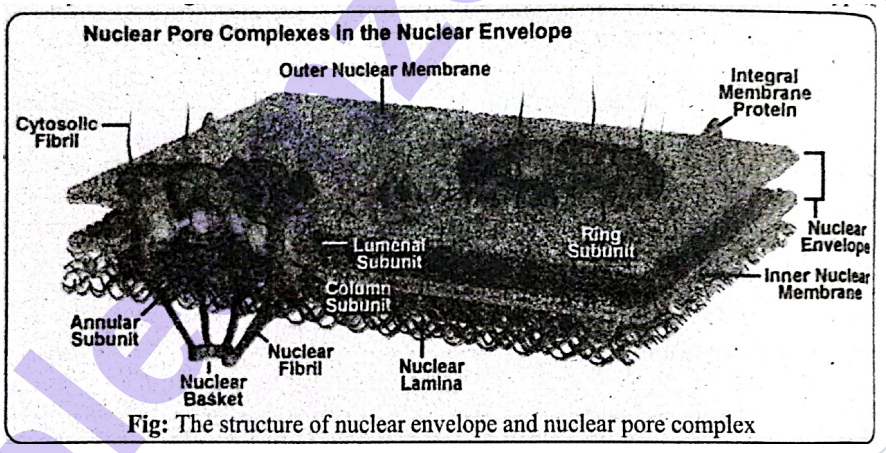
c. Nuclear lamina: a protein lining on the inner side of the nuclear envelope. It binds to chromatin to give it structural support.



Structure of nucleus

d. Nuclear pores

i. The nuclear envelope has tiny holes known as nuclear pores, which regulate the passage of molecules between nucleus and cytoplasm.
ii. They are permeable to small molecules; some larger proteins, e.g. histones, are also allowed to enter.
iii. A nuclear pore is made of an elaborate structure, the **nuclear pore complex**, with several subunits: **annular** (surrounding the inside of the pore), **column** (making the wall), **ring** (attached to the outer side of the column subunit) and **luminal** (anchoring the complex into the nuclear envelope).

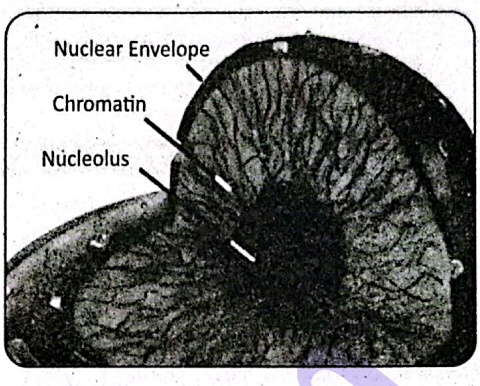


Structure of nuclear envelope and nuclear pore complex

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e. Nucleolus

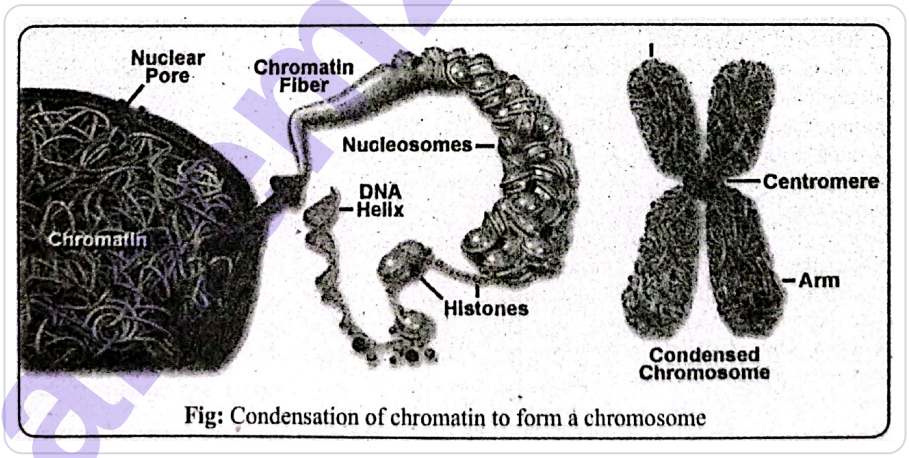
i. A prominent darkly stained structure in the nucleoplasm; there may be one or two nucleoli.
ii. Nucleoli manufacture the subunits that combine to form ribosomes.
iii. They are formed at certain sites in chromosomes called **Nucleolus Organizer Regions (NORs)**; DNA at NORs encodes ribosomal RNA (rRNA).
iv. The nucleolus consists of granular and fibrillar components and DNA. Granules consist of ribosomal subunits already formed; fibrils are the raw materials, i.e. rRNA molecules and associated proteins.



The nucleolus within a nucleus

f. Chromatin and chromosomes

i. The nucleus contains string-like fibres, collectively called chromatin, composed of DNA and proteins.
ii. Chromatin is made of a series of bead-like structures called **nucleosomes**; in a nucleosome a DNA strand wraps around groups of small proteins called **histones**.
iii. During interphase the chromatin is dispersed throughout the nucleus as a tangle of fibres. When the cell begins to divide, chromatin strands are compressed into **chromosomes**.
iv. A chromosome is made of arms called **chromatids** and a central point called the **centromere**.
v. The number of chromosomes is **species-specific**. Human diploid cells have 46 chromosomes. The number may be as low as 2 in some ants and roundworms, or more than a thousand as in the Indian fern (*Ophioglossum reticulatum*) with 1,260 chromosomes. So the chromosome number does not correlate with complexity of the organism.



Condensation of chromatin to form a chromosome

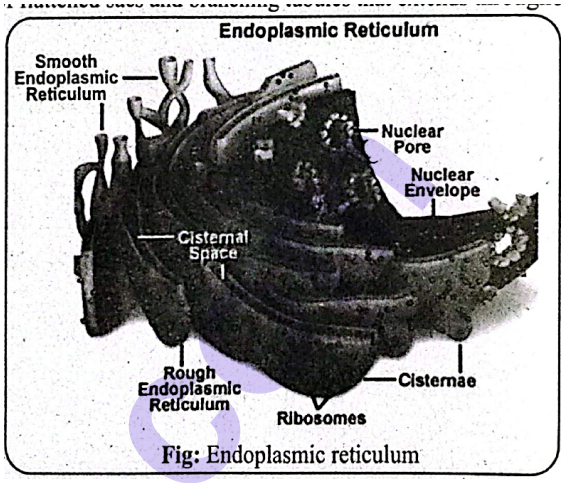
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Endoplasmic Reticulum

Q14 **Explain structure and function of endoplasmic reticulum.**

A. Structure

1. **Cisternae:** a network of flattened sacs and branching tubules extending throughout the cytoplasm; these sacs and tubules are called cisternae (singular cisterna).
2. **Cisternal space:** all cisternae are interconnected so the ER has only one large, highly convoluted lumen, the cisternal space. It takes up more than **10 percent** of the total volume of a cell.
3. **Double-layered:** the cisternae are connected to the double-layered nuclear envelope, so the ER provides a pipeline between nucleus and cytoplasm.



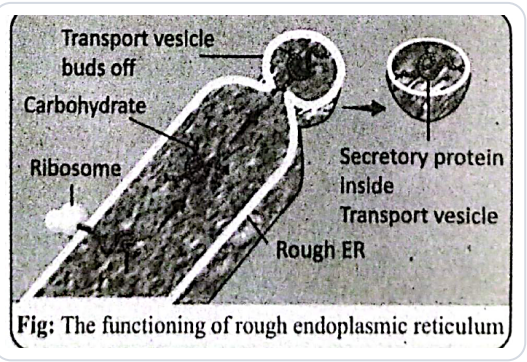
Endoplasmic reticulum

B. Function

The ER manufactures, processes and transports a wide variety of biochemical compounds for use inside and outside the cell.

C. Kinds of endoplasmic reticulum

a. Rough ER (RER): its surface is covered with ribosomes, giving it a bumpy appearance. **Function:** mainly involved in production and processing of **proteins**. It adds other chemicals (e.g. sugars) to proteins, then transports the processed proteins to areas of the cell where they are needed, or sends them to the Golgi apparatus for further processing and modification.



Functioning of rough endoplasmic reticulum

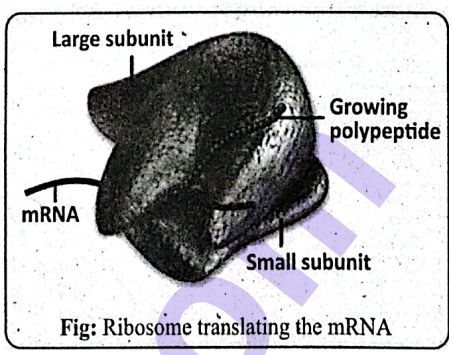
b. Smooth ER (SER): lacks ribosomes, so it appears smooth; in most cells it is much less extensive than RER. **Functions:** (i) production of **lipids**, building blocks for carbohydrate metabolism (ii) **detoxification** of drugs and poisons (iii) storing calcium and calcium metabolism (iv) in muscle cells, SER releases calcium to trigger muscle contraction.

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Ribosomes

Q15 **Explain structure and role of ribosomes in protein synthesis.**

- All living cells contain ribosomes — tiny granular structures composed of approximately **60% rRNA and 40% protein**.
- Ribosomes are not bound by a membrane and are much smaller than other organelles.
- In eukaryotic cells ribosomes are mainly attached to RER and some are scattered freely; in prokaryotic cells all are freely scattered in the cytoplasm. They serve as the protein-production machinery.
- They are most abundant in cells active in protein synthesis, such as pancreas and brain cells. A typical cell contains several thousand ribosomes; some contain a few million.



Ribosome translating the mRNA

- Eukaryotic ribosomes are produced and assembled in the nucleolus. Ribosomal proteins enter the nucleus and combine with rRNA strands to create the two subunits (one small and one large).
- The subunits leave the nucleus through nuclear pores. In the cytoplasm both subunits combine for protein synthesis; when not synthesizing protein, they get separated.
- Protein synthesis requires two other kinds of RNA. **mRNA** provides the instructions taken from DNA; **tRNA** brings amino acids to the ribosome. Once the chain of amino acids is synthesized, the ribosome releases it.
- Subunits are described by their **Svedberg (S)** values, based on their rate of sedimentation in a centrifuge. The eukaryotic ribosome is **80S** (subunits 40S and 60S); prokaryotic cells have **70S** ribosomes (subunits 30S and 50S).

Mitochondria

Q16 **Explain structure and function of mitochondria.**

Structure

- Mitochondria (sing. mitochondrion) are **rod-shaped** organelles considered the **power generators** of the cell, bounded by two membranes with a narrow intermembrane space; beneath the inner membrane is a larger internal **matrix**.
- The outer membrane is smooth and acts like a sieve, filtering out molecules that are too big. The inner membrane is highly convoluted, forming infoldings called **cristae**, which increase the surface area.
- The inner surface of cristae has knob-like extensions into the matrix, known as **F-1 particles**; these are actually enzymes called **ATP-synthase**. Other complexes in the inner membrane serve as electron carriers in the electron transport chain.

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- Mitochondria differ from most other organelles: each has its **own circular DNA** (like prokaryotes), all kinds of RNA and 70S ribosomes, and can **replicate independently** of the cell.

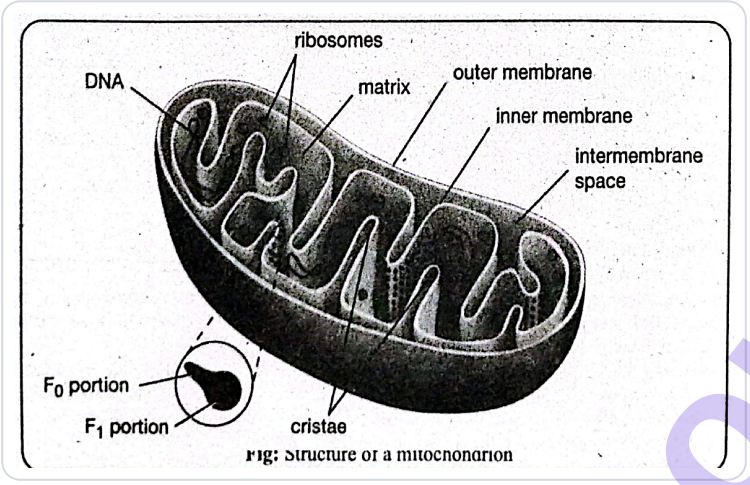


Fig: Structure of a mitochondrion

Structure of a mitochondrion

Functions

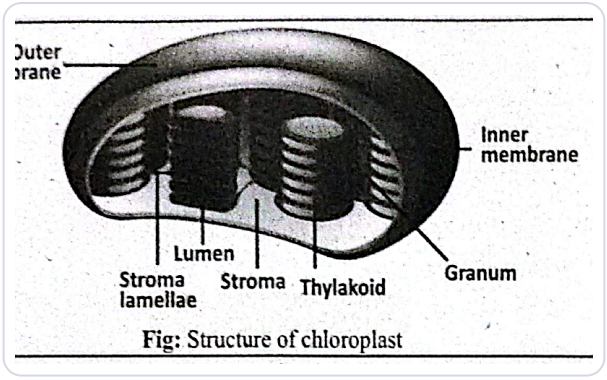
- Sites of **cellular respiration**; they generate ATP from oxygen and nutrients. ATP is the chemical energy "currency" of the cell.
- Enzymes in the matrix catalyse steps of cellular respiration like the Krebs cycle and ETC. Proteins of the **electron transport chain** are found on the inner membrane.

Chloroplast

Q17 **Explain structure and function of chloroplasts.**

- **Importance:** plants make their own food by photosynthesis, converting light energy into chemical energy, in organelles called chloroplasts.
- **Occurrence:** all green structures of plants, including stems and unripened fruit, contain chloroplasts, but most photosynthesis occurs in the leaves. On average, chloroplast density on a leaf surface is about **half a million per square millimetre**.
- **Pigments:** chlorophyll "a" and chlorophyll "b", which absorb the light energy needed for photosynthesis.
- **Intermembrane space:** the ellipsoid chloroplast is enclosed by two membranes; the area between them is the intermembrane space.
- **Stroma:** a semi-fluid inside the inner membrane containing dissolved enzymes; it comprises most of the chloroplast's volume.
- **Membranes:** the outer membrane is much more permeable than the inner layer. Inner membranes lie close together and fuse along their peripheries, forming disk-shaped compartments called **thylakoids**.
- **Grana:** many thylakoids form stacks called grana (singular granum); a chloroplast may contain a hundred or more grana. **Lamellae** are the non-green compartments that connect two grana.
- **Own DNA:** like mitochondria, chloroplasts have their own DNA and reproduce independently of the cell.

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Structure of chloroplast

Functions

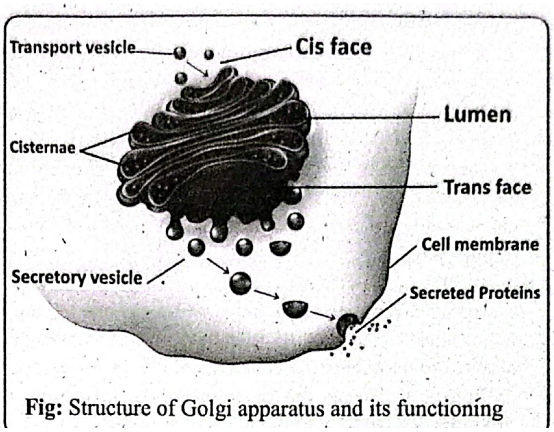
- Light is absorbed by chlorophyll molecules embedded in the thylakoid disks; they emit electrons and ATPs are formed.
- Using these ATPs, in the stroma, low-energy carbon dioxide is transformed into a high-energy compound like glucose.

Golgi Apparatus

Q18 **Write note on structure and functions of Golgi apparatus.**

Structure

- **Discovery:** Golgi apparatus was discovered by **Camillo Golgi**.
- **Cisternae:** five to eight cup-shaped, membrane-covered sacs stacked over each other. In some unicellular flagellates it may consist of 60 cisternae.
- Found in cells of plants, animals and unicellular eukaryotes. Animal cells generally contain **10–20 Golgi stacks**; usually located close to the nucleus.
- Each stack has two faces: the **cis face** near the ER and the **trans face** near the plasma membrane.



Golgi apparatus and its functioning

Functions

- The **distribution and shipping department** for the cell's chemical products. It **modifies proteins and lipids** built in the ER and prepares them for export or transport within the cell.
- Small vesicles containing proteins, carbohydrates, phospholipids etc. bud off from the ER, reach the cis face and fuse with the Golgi. The compounds are processed; enzymes in the Golgi lumen convert them into **glycoproteins and glycolipids**.
- The product is extruded from the trans face in a vesicle to its final destination; exported products are known as **secretions**. Other products are returned to the ER or mature into **lysosomes**.

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- In plant cells, the Golgi produces **pectin and other polysaccharides** needed for plant structure and metabolism.

Lysosomes

Q19 **Give detail structure and functions of lysosomes.**

Structure

- **Discovery:** by Belgian scientist **Christian de Duve**. They contain strong digestive enzymes.
- Spherical organelles bounded by a **single membrane**; digestive compartments of the cell, found in most eukaryotic cells.
- In animals they are most numerous in disease-fighting cells, such as white blood cells, which digest bacteria, viruses and foreign intruders.
- Lysosomes have about **40 different hydrolytic enzymes**, manufactured in the ER and modified in the Golgi apparatus.

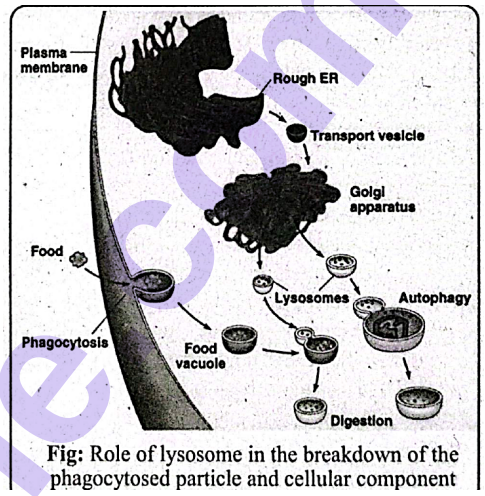


Fig: Role of lysosome in the breakdown of the phagocytosed particle and cellular component

Role of lysosome in breakdown of phagocytosed particle and cellular component

Functions

- The lysosome membrane **protects** the rest of the cell from the harsh digestive enzymes.
- They break down cellular materials which have exceeded their lifetime — **autophagy** (self-eating).
- They break down cellular waste, fats, carbohydrates, proteins and other macromolecules into simple compounds which are returned to the cytoplasm (**recycling**).
- Elimination of whole cells — **apoptosis**; e.g. when a tadpole develops into a frog, tail cells are destroyed by lysosomal enzymes.

Lysosomal storage diseases

The patient lacks one of the hydrolytic enzymes; the abnormal lysosome fills with indigestible substances. **Pompe's disease:** the lysosome lacks a glycogen-digesting enzyme, so glycogen accumulates in liver cells. **Tay-Sachs disease:** an essential lipid-digesting enzyme is missing; lipids accumulate in nerve cells of the brain, causing mental retardation and death in early childhood.

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Peroxisomes and Glyoxysomes

Q20 **Write note on peroxisomes. What is consequence of defects in peroxisome? Also describe the location and function of glyoxysomes.**

Peroxisomes are single-membrane-bounded organelles in all eukaryotic cells, discovered by **Christian de Duve**. They contain a variety of enzymes, many of which are oxidative (removal of electrons and hydrogens).

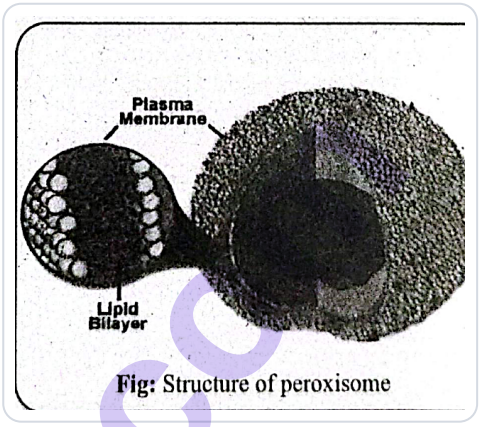


Fig: Structure of peroxisome

Structure of peroxisome

Functions

- Rid the cell of toxic substances. Some, e.g. in liver cells, detoxify alcohol and other harmful compounds by oxidation.
- Some contain **catalase**, which breaks down hydrogen peroxide (a by-product of metabolism) into water and oxygen:

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Defects: defects in peroxisomes cause metabolic disorders; the most serious is **Zellweger syndrome** — absence or reduced number of peroxisomes. It is a congenital disorder with no cure and usually causes death within the first year of life.

Glyoxysomes

Location: similar to peroxisomes but found **only in plant cells**, most abundant in cells of lipid-rich seeds (e.g. castor beans and soyabeans). **Function:** they contain enzymes that convert stored lipids into carbohydrates that provide energy for seed germination.

Vacuoles

Q21 **Write note on vacuoles.**

Definition: vacuoles are membrane-bound sacs found in both animal and plant cells with different functions.

Position and formation in plant cells: many plant cells have a large single central vacuole, developed by fusion of smaller vacuoles; it occupies 80% or more of the space in plant cells.

Structure: (a) **Tonoplast** — the membrane surrounding the plant vacuole. (b) **Cell sap** — the material inside the vacuole, which differs markedly from the surrounding cytoplasm.

Functions

a. **In mature plant cells:** provides structural support and serves in storage, waste disposal, protection and growth.
b. **In animal cells:** vacuoles are much smaller and temporarily store or transport substances.

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c. **Turgor pressure:** the central vacuole controls turgor pressure, which gives rigidity to the cell. With adequate water, central vacuoles swell, creating high turgor pressure that maintains structural integrity along with the cell wall.
d. **Store pigments** that give flowers their colours, attracting bees and other pollinators.
e. **Protection:** vacuoles release molecules poisonous to insects and animals, discouraging them from consuming the plant.

Centrioles and Cytoskeleton

Q22 Write short note on centrioles.

In cells of animals and most protists, centrioles are organelles associated with assembly and organization of the fibres of the cytoskeleton, i.e. microtubules (including spindle fibres).

In eukaryotic cells centrioles occur **in pairs**, located at right angles to one another near the nuclear envelope. In ciliated or flagellated cells they are involved in forming cilia and flagella; each cilium and flagellum is anchored by a centriole known as the **basal body**.

Cells of **plants and fungi lack** centrioles and basal bodies; their microtubules and spindle fibres are organized from structures of the cytoplasm.



Centrioles (microtubule triplets)

Q23 What is cytoskeleton? Give its composition and functions.

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

1. Microfilaments: present in all eukaryotic cells; solid rods made of a globular protein called **actin**. They disassemble and reassemble and help the cell change shape and move; they enable a dividing cell to pinch off into two cells; with myosin they help in muscle contraction.

2. Microtubules: straight, hollow cylinders of subunits; each subunit is made of two different **tubulin** proteins (α-tubulin and β-tubulin). They give structure and shape to a cell, serve as highways for transport of organelles, and are the major components of cilia and flagella; they form spindle fibres during cell division.

3. Intermediate filaments: found only in some higher animal groups. Made of different proteins, most commonly **vimentin**; some cells have others, e.g. skin cells contain **keratin**. They maintain cell shape and rigidity and anchor several organelles, including the nucleus.

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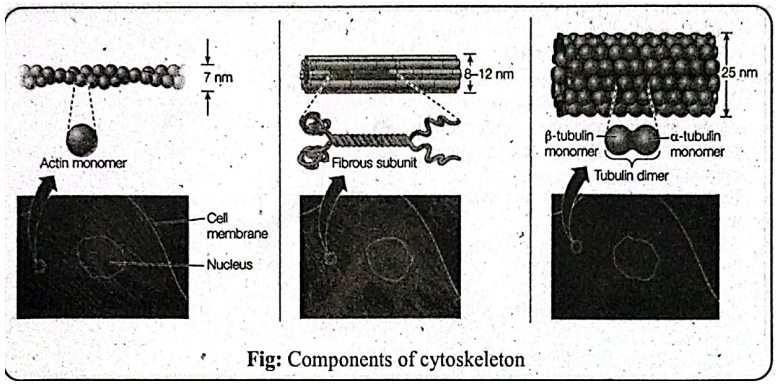


Fig: Components of cytoskeleton

Components of cytoskeleton

Cilia and Flagella

Q24 **Write a note on cilia and flagella.**

- Cilium (plural cilia) and flagellum (plural flagella) are the locomotor appendages that protrude from certain cells — thin, tail-like projections.
- Cilia are short and numerous; flagella are longer but less numerous.
- Cilia are rare in plants. Many protozoans (ciliates) possess cilia, e.g. *Paramecium*. In humans, cilia line the trachea, where they sweep mucus and dirt out of the breathing tubes.

Structure

- The core of eukaryotic cilia and flagella is the **axoneme**: two central microtubules surrounded by an outer ring of nine doublet microtubules — the **“9 + 2” structure**.
- **Dynein** molecules around the axoneme bridge the gaps between adjacent doublets. A plasma membrane surrounds the axoneme.
- At the base is the organizing centre, the **basal body**: like the axoneme’s outer ring but each of the nine sets is three microtubules (triplets). The basal body is actually a modified centriole.
- Prokaryotic flagella have a completely different structure built from the protein **flagellin**.

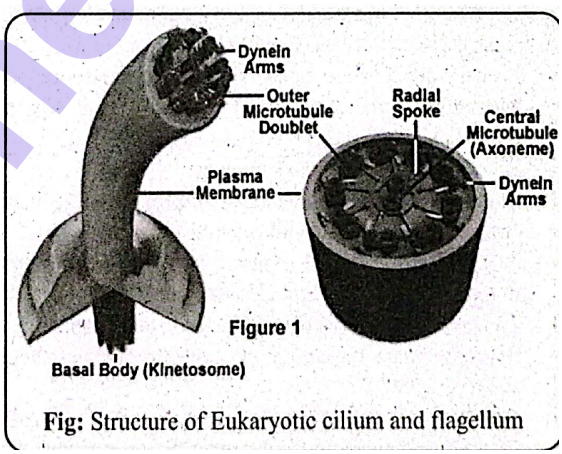
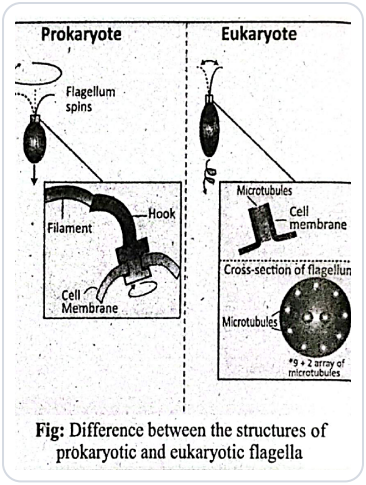


Fig: Structure of Eukaryotic cilium and flagellum

Structure of eukaryotic cilium and flagellum

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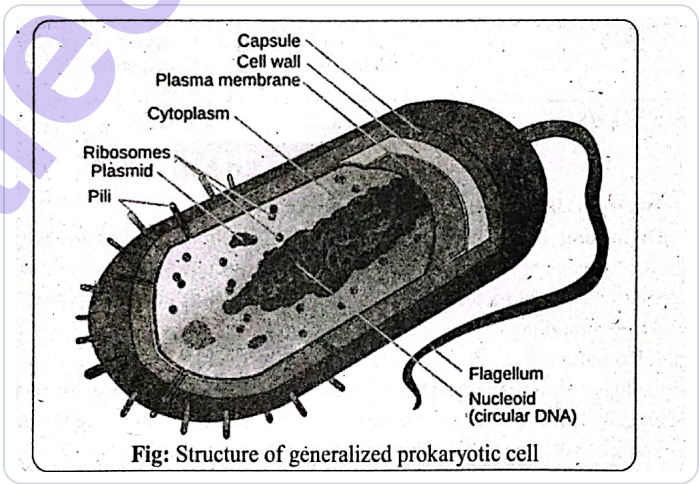
Prokaryotic vs eukaryotic flagella

Prokaryotic and Eukaryotic Cells

Q25 **Write characteristics of prokaryotic cells.**

Bacteria and archaea are made up of prokaryotic cells:

- Much simpler than eukaryotic cells; most are **2 to 8 µm** long, about one-tenth the size of a typical eukaryotic cell.
- No nucleus; the much less extensive DNA is in a central region called the **nucleoid** (nucleus-like).
- No membrane-bounded organelles like ER, mitochondria, chloroplasts, Golgi, lysosomes, peroxisomes. The cytoplasm is one unit with no internal support structures.
- Ribosomes are smaller: subunits **30S and 50S**; complete ribosome **70S**.
- Most have a cell wall of **peptidoglycan** (not cellulose); may have a capsule and **pili** for attachment.
- Flagella are made of repeating units of the protein **flagellin**, with no microtubule triplets.
- Mitosis and meiosis are missing; the cell divides by direct division (**binary fission**).



Structure of generalized prokaryotic cell

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Q26 **Give difference between eukaryotic and prokaryotic cells.**

#	Characteristic	Eukaryotic cell	Prokaryotic cell
1	Distinct nucleus	Present	Absent
2	Number of chromosomes	More than one	One — but not a true chromosome; plasmids
3	Cell type	Usually multicellular (protozoans, algae, fungi, animals, plants)	Usually unicellular (some cyanobacteria may be multicellular): bacteria and archaea
4	Lysosomes and peroxisomes	Present	Absent
5	Microtubules	Present	Absent or rare
6	Endoplasmic reticulum	Present	Absent
7	Mitochondria	Present	Absent
8	Cytoskeleton	Present	May be absent
9	Vacuoles	Present	Absent (gas vacuoles in some)
10	Ribosomes	Larger (80S)	Smaller (70S)
11	Golgi apparatus	Present	Absent
12	Chloroplasts	Present (in plants)	Absent; chlorophyll scattered in the cytoplasm
13	Cell division	Mitosis or meiosis	Mitosis and meiosis missing; direct division (binary fission)
14	Flagella	Membrane-bounded; two central microtubules surrounded by an outer ring of nine doublets	Not membrane-bounded; repeating units of flagellin; no microtubule triplets
15	Cell wall	Only in plant cells and fungi (chemically simpler)	Peptidoglycan (a single large polymer of amino acids and sugar)
16	Cell size	10–100 µm	1–10 µm

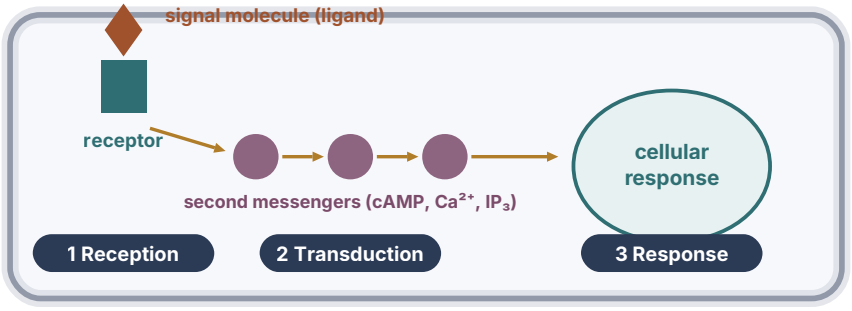
Row 9: the notes write “Present” for prokaryotes; prokaryotic cells lack true vacuoles (some have gas vacuoles), so this has been corrected.

Cell Signalling

Q27 **What is cell signalling? Explain various steps in it.**

Definition: cell signalling is the ability of cells to respond to stimuli from their environment, producing cellular responses. It involves transmission of signals between cells through a series of molecular events, often leading to a cellular response.

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Steps of cell signalling

1. Signal reception: begins when a signal molecule (**ligand**) binds to a receptor on the membrane of a target cell. Receptors are typically proteins embedded in the cell membrane but can also be inside the cell. Each receptor is specific to a particular ligand.

2. Signal transduction: once the receptor binds the ligand, it undergoes a conformational change that activates an intracellular signalling pathway, often a series of interactions creating a **signalling cascade** that amplifies the signal. Small molecules like **cAMP**, calcium ions and inositol triphosphate (**IP3**) act as **second messengers**.

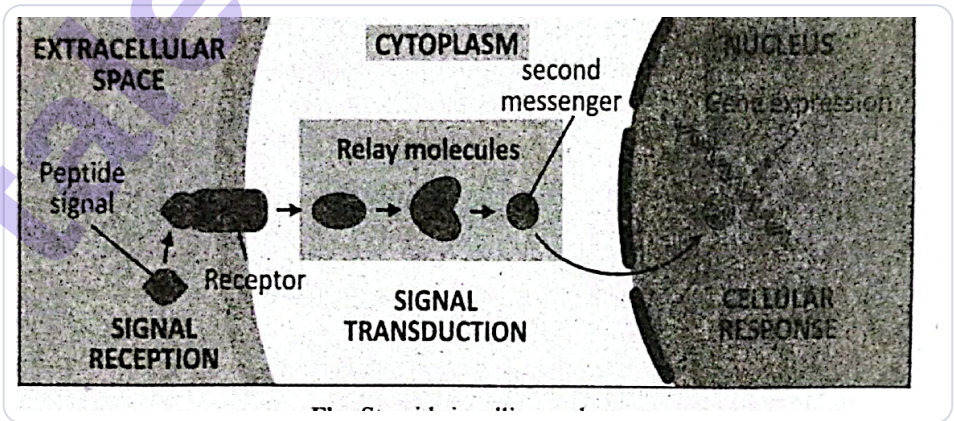
3. Cellular response: the pathway leads to changes in gene expression (turning specific genes on or off), resulting in cell growth, division, differentiation or apoptosis (programmed cell death). It can also change cellular metabolism, enzyme activity, or opening/closing of ion channels.

Q28 Explain pathways of cell signals from outside to inside.

Cell-signalling pathways transmit signals from the cell's exterior to its interior, resulting in a specific cellular response. Two main types: (i) protein/peptide signalling (ii) steroid signalling.

(i) Protein / peptide signalling

- Protein or peptide signalling molecules are **water-soluble**, so they **cannot pass** through the plasma membrane.
- The ligand binds to its specific **receptor on the plasma membrane**, causing a conformational change that activates it; the activated receptor triggers a series of reactions in the cell.
- These generate **second messengers** like cyclic AMP (cAMP), which start changes, e.g. in gene expression — leading to changes in metabolism, growth, division or apoptosis.



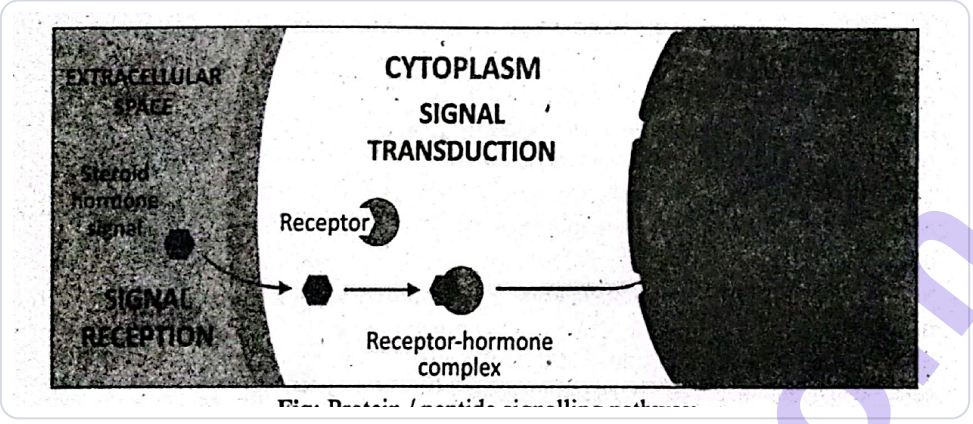
Protein / peptide signalling pathway (receptor on membrane, second messenger)

(ii) Steroid signalling

- Steroid hormones are **lipophilic**, so they diffuse through the plasma membrane.

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- Inside, they bind to specific **intracellular receptors** in the cytoplasm or nucleus, forming an active **receptor–hormone complex**, which moves into the nucleus if not already there.
- There it binds specific DNA sequences and regulates **transcription** of these genes, increasing or decreasing production of specific proteins.



Steroid signalling pathway (intracellular receptor–hormone complex)

The two figure captions are swapped in the notes; each figure is now placed with its correct pathway.

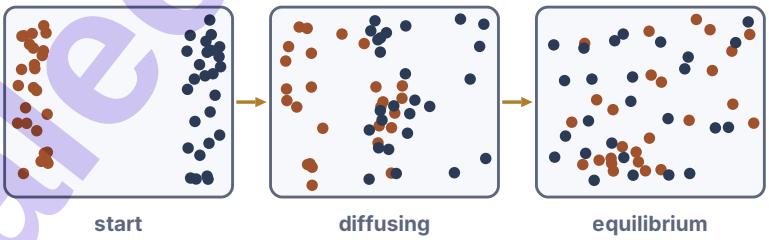
Membrane Transport Mechanisms

Q29 **Explain passive transport and its types.**

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

a. Diffusion

The net movement of a substance (liquid or gas) from an area of higher concentration to lower concentration, i.e. along the concentration gradient. The cell expends no energy, so diffusion is a type of passive transport.

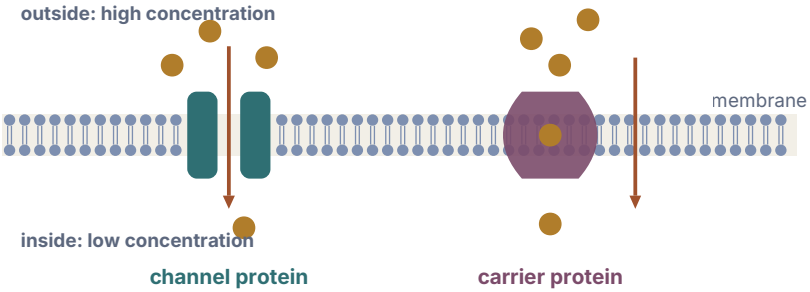


Diffusion of two types of molecules

b. Facilitated diffusion

Some molecules are taken into or out of cells with the help of **transport proteins** in the plasma membrane. When a transport protein helps a substance move down its concentration gradient, the process is facilitated diffusion — also passive, as no energy is used. Its rate depends on how many transport-protein molecules are available.

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Facilitated diffusion through channel and carrier proteins

1. **Channel proteins** form hydrophilic channels that allow specific molecules or ions to pass. They can be **gated** (open or close in response to stimuli such as voltage changes, ligand binding or mechanical stress) or **non-gated** (remain open). Examples: ion channels (Na^+, K^+, Ca^{2+}, Cl^-) and **aquaporin** (rapid transport of water).
2. **Carrier proteins (transporters)** bind the specific molecule, undergo a conformational change and move it across. They are highly specific and can become **saturated** (maximum rate when all carriers are occupied), e.g. glucose transporters and amino-acid transporters.

Q30 Give difference between simple and facilitated diffusion.

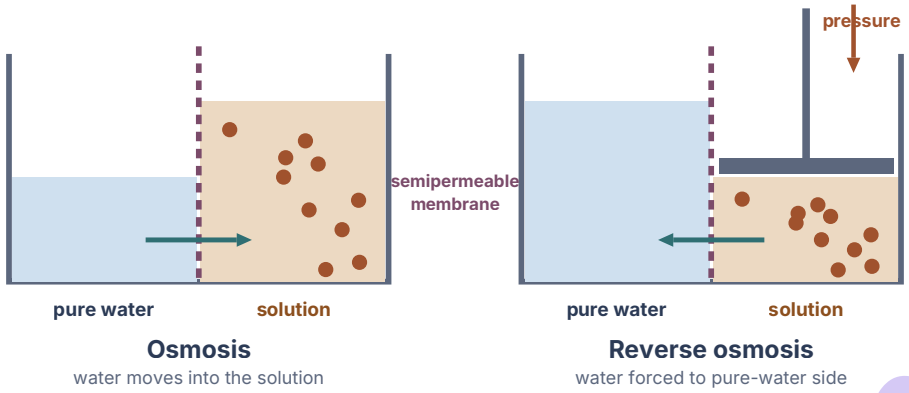
	Simple diffusion	Facilitated diffusion
Mechanism	Substances move from higher to lower concentration directly through the lipid bilayer.	Substances move from higher to lower concentration through specific transport proteins embedded in the membrane.
Energy	Passive; no energy input from cell.	Also passive; no energy required.
Types of molecules	Small, nonpolar molecules such as oxygen, carbon dioxide and lipid-soluble substances.	Polar or charged molecules such as glucose, amino acids and ions, which cannot easily pass the hydrophobic core.
Rate	Depends on concentration gradient, temperature and membrane permeability.	Affected by number and availability of transport proteins; reaches a maximum when all are saturated.

Q31 Write note on osmosis and reverse osmosis.

Osmosis: the process by which water molecules diffuse across a cell membrane from an area of higher (water) concentration to an area of lower concentration.

- **Passive transport:** water moves down its gradient, so the cell expends no energy.
- **Direction:** depends on the concentration of solutes on the two sides; water always moves from a **hypotonic** solution (lower solute concentration) to a **hypertonic** solution (higher solute concentration).
- **Selectively permeable membrane:** lets water pass while restricting many solutes.
- **Cell turgor:** osmosis maintains turgor, vital for plant cells, and balances water content in cells. Its rate depends on the osmotic gradient and membrane permeability.
- **Aquaporins** are specialized proteins that facilitate rapid water transport across the membrane.

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Osmosis and reverse osmosis

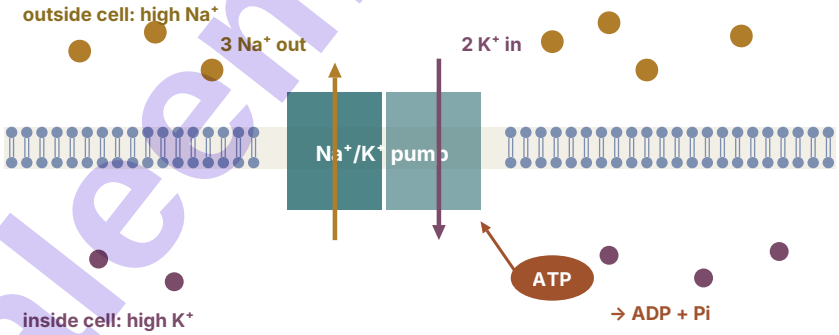
Reverse osmosis

- A widely used technology for purifying water by removing contaminants and impurities.
- Unlike natural osmosis (water moves from lower to higher solute concentration), reverse osmosis applies **external pressure** to push water through a semipermeable membrane from a higher to a lower solute concentration.
- It filters out dissolved salts and other impurities, providing clean drinking water; used in water-treatment plants, desalination facilities and household purification systems.

Q32 **What is active transport? Explain its types.**

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

1. Active transport through carrier proteins: carrier proteins use energy to move molecules against the concentration gradient, e.g. the **sodium–potassium pump** of nerve cells. In a resting nerve cell, the pump spends ATP to maintain a higher concentration of K^+ and lower concentration of Na^+ inside the cell, actively moving Na^+ out and K^+ in.

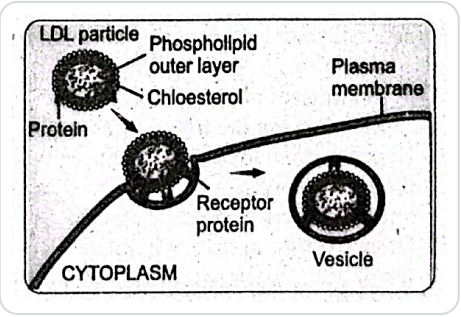


Active transport through carrier proteins (Na^+/K^+ pump)

2. Endocytosis: bulky materials are moved into the cell — a portion of the membrane invaginates, the material is taken in, the ends seal and a small vesicle detaches into the cytoplasm. Two forms: (a) **phagocytosis** — cell takes in solid material (b) **pinocytosis** — cell takes in liquids as droplets.

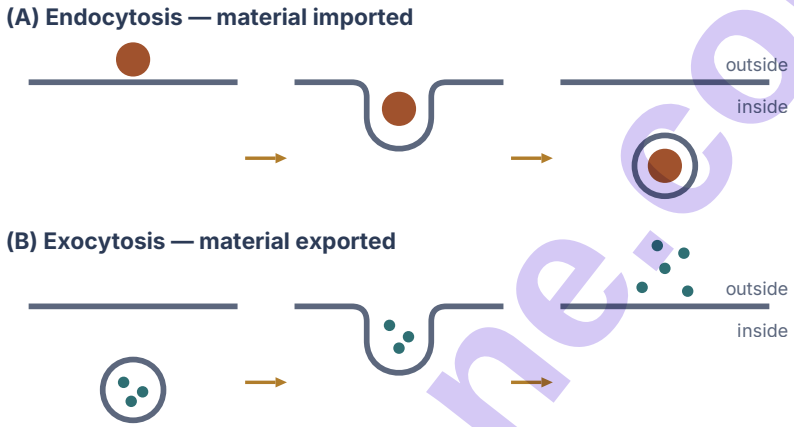
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Receptor-mediated endocytosis: specific receptor proteins pick up material from outside and pinch inside to form a vesicle. E.g. liver cells have receptor proteins for cholesterol carried in the blood as **low-density lipoproteins (LDLs)**; they recognize and take up LDLs.



Receptor-mediated endocytosis

3. Exocytosis: bulky material is packed inside a membrane vesicle, which moves to the plasma membrane and fuses with it, releasing its contents outside.



(A) Endocytosis (B) Exocytosis

Stem Cells

Q33 **What are stem cells? Describe their categories on the basis of types of cells they make.**

Stem cells are unique cells able to develop into many different cell types. When a stem cell divides, each new cell may remain a stem cell or become specialized, such as a muscle cell, red blood cell or brain cell.

1. **Totipotent:** can differentiate into all possible cell types, e.g. zygote and cells of its first few divisions.
2. **Pluripotent:** can turn into almost any cell, e.g. cells of the early embryo.
3. **Multipotent:** can differentiate into a closely related family of cells, e.g. haematopoietic stem cells → red and white blood cells or platelets.
4. **Oligopotent:** can differentiate into a few cell types, e.g. adult lymphoid or myeloid stem cells.
5. **Unipotent:** produce cells of only one kind (their own type) but still renew themselves, e.g. adult muscle stem cells.

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Q34 Write uses of stem cells.

i. **Regenerative medicine:** stem cells can repair or replace damaged tissues and organs — used for spinal cord injuries, type 1 diabetes, Parkinson's disease and heart disease.
ii. **Drug testing and development:** differentiating stem cells into specific cell types gives models of human diseases for more accurate drug testing, reducing reliance on animal models.
iii. **Personalized medicine:** stem cells derived from a patient's own cells reduce the risk of immune rejection, making therapies more effective and safer.

Q35 Explain different categories of stem cells on the basis of their origin.

1. Embryonic stem cells (ESCs): derived from the inner cell mass of blastocysts (early-stage embryos). They are **pluripotent** with high differentiation potential, very versatile for research and therapy. Ethical concerns include use of human embryos, risk of teratoma formation and potential immune rejection.

2. Adult stem cells (ASCs): found in tissues such as bone marrow, fat and blood. They are **multipotent** — differentiate into a limited range of cell types related to their tissue of origin. Less ethical controversy, lower risk of rejection (when from the patient's own tissue), but limited potential and harder to isolate and culture.

3. Induced pluripotent stem cells (iPSCs): generated in the lab by reprogramming adult somatic cells to a pluripotent state using specific transcription factors.

- **Advantages:** no ethical controversy (no embryo destruction); can be made from a patient's own cells, minimizing rejection; potential for regenerating damaged tissues (e.g. heart cells, neurons for neurodegenerative conditions).
- **Disadvantages:** reprogramming can introduce genetic changes; they could form tumours (teratomas) when transplanted; directing them into specific, fully functional cell types is complex.

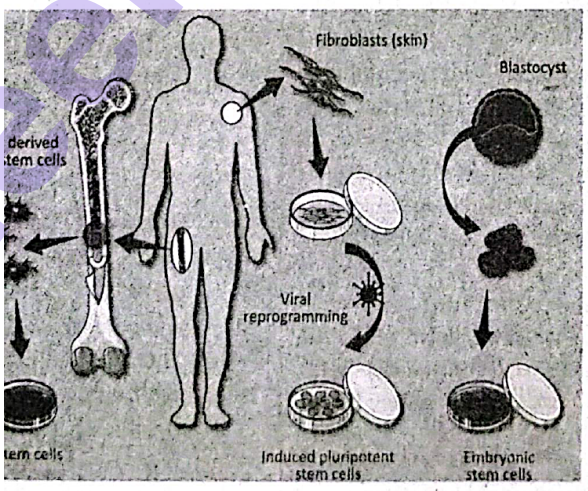


Fig: Stem cells – sources and types

Stem cells — sources and types

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PART B

Short Questions

Exercise Short Questions

Q1 Compare the resolution and magnification of light microscope and electron microscope.

(a) Resolution of light microscope is **0.2 µm** while its magnification is **1500X**.
(b) Resolution of electron microscope is **0.2 nm**, while it can magnify objects up to **250,000 times**.

Q2 State the cell theory. How we can validate it? What are the exceptions to cell theory?

1. Cell theory: all living organisms are made of cells and cell products. Three essential points: (i) all living organisms are composed of one or more cells (ii) cells are the basic units of structure and function (iii) cells come only from pre-existing cells.
2. Validation: (i) visualizing cell structure under microscope (ii) live-cell imaging and genetic studies (iii) DNA sequencing and metabolic pathways (iv) cell-culture studies and tissue engineering.
3. Exceptions: (a) viruses — not made of cells, can't carry out life processes independently (b) prions and viroids (c) multinucleated muscle cells in vertebrates (d) multinucleated organisms like certain fungi and algae (e) self-replication of mitochondria and chloroplasts.

Q3 The table below compares the process of diffusion, facilitated diffusion and active transport. Fill in the blank cells, using the words "YES" or "NO".

Description	Simple diffusion	Facilitated diffusion	Active transport
Is ATP required?	NO	NO	YES
Are carrier proteins involved?	NO	YES	YES
Is direction of transport always from higher to lower concentration?	YES	YES	NO

Q4 Categorize the organelles as (i) single membrane bounded (ii) double membrane bounded and (iii) lacking any membrane.

(i) **Single membrane:** lysosomes, peroxisomes, glyoxysomes, endoplasmic reticulum, Golgi apparatus, vacuoles.
(ii) **Double membrane:** mitochondria, chloroplast, nucleus.
(iii) **Lacking membrane:** ribosomes, centrioles, cytoskeleton, nucleolus.

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Q5 State two functions of the proteins in the plasma membrane.

(i) **Transport:** some proteins act as channels or carriers to transport substances like glucose or amino acids across the membrane.
(ii) **Cell signalling:** receptor proteins receive chemical signals from outside the cell and transmit them into the cell for a response.

Q6 State two features that mitochondria have in common with prokaryotes.

(i) **Circular DNA:** like prokaryotes, mitochondria contain their own circular DNA.
(ii) **Self-replication:** mitochondria replicate independently of the nucleus, similar to prokaryotes.

Q7 List three ways in which prokaryotic cells differ from eukaryotic cells.

1. Eukaryotic cells have a distinct nucleus; it is absent in prokaryotes.
2. Eukaryotic ribosomes are 80S; prokaryotic are 70S.
3. Mitosis and meiosis are present in eukaryotic cells but absent in prokaryotic cells.

Q8 List the structures and molecules, which can cross the nuclear envelope.

(a) Small molecules pass through the permeable nuclear pores.
(b) Some large proteins like histones also pass the nuclear membrane.
(c) Ribosomal subunits also pass out through the nuclear membrane.

Q9 Distinguish each of the following pairs: a. Exocytosis and endocytosis b. Phagocytosis and pinocytosis c. Peroxisome and glyoxysomes

Exocytosis	Endocytosis
Bulky material is exported out of the cell.	Bulky material is moved into the cell across the plasma membrane.
Material is packed inside a membrane vesicle, which fuses with the plasma membrane to release its contents.	The membrane engulfs the material, forming a vesicle which detaches and moves into the cytoplasm.

Phagocytosis	Pinocytosis
Endocytosis in which the cell takes in solid material.	Endocytosis in which the cell takes in liquids as droplets.
Also called cell eating.	Also called cell drinking.

Peroxisomes	Glyoxysomes
Break down fatty acids and detoxify hydrogen peroxide.	Convert stored lipids into carbohydrates during seed germination.
Found in most eukaryotic cells.	Found only in plant cells; abundant in lipid-rich seeds.
Contain catalases and oxidases.	Contain enzymes that convert lipids into carbohydrates.

Q10 What are the main functions of lysosomes?

Lysosomes are membrane-bound organelles containing digestive enzymes to break down macromolecules, damaged organelles and foreign particles. They play a key role in intracellular digestion and recycling of cellular components, often called **autophagy**.

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Q11 **Describe the role of the Golgi body.**

(i) Involved in production of cell secretions. (ii) Converts proteins and lipids into glycoproteins and glycolipids. (iii) In plant cells it produces pectin and other polysaccharides needed for plant structure and metabolism.

Q12 **What are histones? Where are these found in eukaryotic cells?**

Histones are a group of small proteins. A DNA strand wraps around the histone proteins to form a structure called a **nucleosome**, which is part of chromatin in the nucleus.

Q13 **What do you mean by "stem cell"? What are the main usages of stem cells?**

Stem cells are unique cells with the remarkable ability to develop into many different cell types, such as muscle cell, red blood cell or brain cell.
Usage: regenerative medicine, drug testing and development of personalized medicine.

Q14 **The following diagram shows the structure of a mitochondrion. Name structures A to G.**

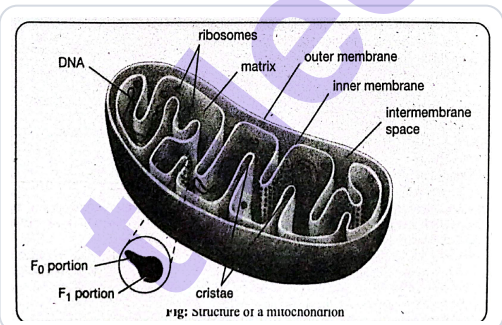


Fig: Structure of a mitochondrion

A – DNA B – Ribosomes C – Matrix D – Inner membrane E – Outer membrane F – F_1 particle G – Cristae

Q15 **The diagram shows an electron micrograph of a cell. a. Label the parts of the cell. b. What evidence can be seen that the cell is metabolically active and involved in secretion of enzymes?**

a.

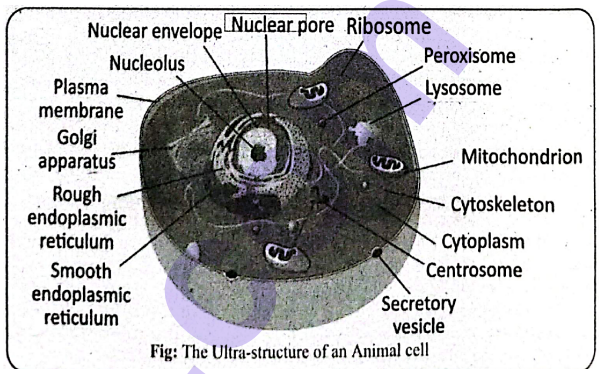


Fig: The Ultra-structure of an Animal cell

b. (i) Many mitochondria are present. (ii) Secretory vesicles come out of the endoplasmic reticulum and form the Golgi apparatus; from the Golgi apparatus vesicles are formed which carry various enzyme secretions.

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SLO-Based Short Questions

Cells — Basic Unit of Life and Cell Theory

Q16 Enlist the fundamental activities performed by cell.

1. Movement 2. Nutrition 3. Respiration 4. Excretion 5. Homeostasis 6. Growth 7. Reproduction.

Q17 What do you know about the discovery of cell.

In 1665 Robert Hooke examined a thin slice of cork of oak tree under a microscope. He observed that cork was made of many little boxes, which he named **cellulae** (cell).

Q18 Give three 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.

Microscopy

Q19 What is main difference between light microscope and electron microscope?

In a light microscope, **light** is used to make the image of an object, while in an electron microscope a **beam of electrons** passes through the object and the image is formed on a screen.

Q20 What is meant by magnification of microscope?

A microscope's ability to enlarge the image of an object. Different lenses offer varying levels of magnification, denoted by 'X', indicating how many times larger the image appears than its actual size, e.g. a 10X lens enlarges a 1 µm object to 10 µm. Total magnification = product of magnifications of all lenses.

Q21 Write about resolution of microscope?

Resolution is a microscope's ability to distinguish between two points that are close together on an object. The greater the resolution, the finer the detail. The naked human eye resolves about 0.1 mm; a light microscope can resolve details down to about 250 nm.

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Q22 What is difference between transmission electron microscope (TEM) and scanning electron microscope (SEM)?

TEM	SEM
Used to view the internal structure of cell.	Used to study the details of surfaces of cells or other objects.
Transmits a beam of electrons through a very thin specimen.	Surfaces are coated with metal; the electron beam is reflected and makes an enlarged image.
Magnifies objects up to 250,000 times.	Magnifies objects up to 100,000 times.

Structure of Cell — Cell Wall

Q23 What is protoplast?

When the cell wall is removed using cell-wall-degrading enzymes, the remaining components of the cell are called a **protoplast**.

Q24 What is primary wall? Give its chemical composition?

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

Q25 What is secondary wall? Give its chemical composition.

In some plant cells, after maturation, a secondary wall is made between the protoplast and primary wall. It is composed of lignin, cellulose and hemicellulose; due to lignin it is more rigid than the primary wall.

Q26 What are plasmodesmata?

Small channels that directly connect the cytoplasm of neighbouring plant cells. They penetrate both primary and secondary walls, allow movement of materials between cells and so are important in cellular communication.

Q27 How plasmodesmata are exception to cell theory?

Plasmodesmata have caused debate 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.

Q28 What are diatoms? Write about their cell walls.

Diatoms are a group of algae that synthesize their cell walls from **silicic acid**. The acid is polymerized inside cells and the wall is extruded to protect the cell. Synthesis of silica walls requires less energy, so diatoms have higher growth rates.

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Q29 **Compare the cell wall composition of algae, fungi, prokaryotes and archaebacteria?**

Algae: cellulose and glycoproteins. **Fungi:** chitin (the same carbohydrate that strengthens insect exoskeletons). **Prokaryotes:** peptidoglycan (a single large polymer of amino acids and sugar). **Archaebacteria:** different polysaccharides and proteins, with no peptidoglycan.

Plasma Membrane

Q30 **What is fluid mosaic model?**

A widely accepted concept describing the dynamic plasma membrane. Its basic foundation is a lipid bilayer of phospholipids with proteins floating within it. The hydrophobic lipid tails are oriented inwards and the hydrophilic phosphate groups are aligned outwards, towards the cytoplasm or the extracellular environment.

Q31 **What is significance of proteins in the lipid bilayer of plasma membrane?**

The interior of the lipid bilayer is hydrophobic and repels water-soluble molecules. A pure lipid bilayer would be impermeable to sugars, polar amino acids etc. So membranes also contain proteins that provide passageways across the membrane.

Q32 **Mention various types of proteins in plasma membrane and write their functions?**

1. **Transporters** — selective transport across the bilayer. 2. **Anchors** — attach the membrane to cytoskeleton and external fibres. 3. **Receptors** — bind messenger molecules and transmit signals inside; some attach with sugar as identification marks. 4. **Enzymes** — show enzymatic activity.

Q33 **What is significance of identification of cells in the body?**

Distinguishing among different cells allows cells in an embryo to sort themselves into tissues and organs. It also helps the immune system recognize and reject foreign cells, e.g. infectious bacteria.

Q34 **How transmission and scanning electron microscopy helped to study structure of plasma membranes?**

(i) TEM reveals detailed structures of the lipid bilayer and associated proteins. (ii) SEM is useful for examining the surface topology of cells and membranes.

Q35 **Write benefits of confocal microscopy and total internal reflection fluorescence microscopy to study structure of plasma membrane.**

(i) Confocal microscopy uses laser scanning and fluorescence to create sharp, detailed images of the membrane. (ii) TIRF microscopy gives high-resolution images of the membrane and its interactions with the cytoskeleton and other components.

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Q36 How atomic force microscopy and X-ray crystallography is useful to study structure of plasma membrane?

(i) Atomic force microscopy provides topographical images of the cell membrane at high resolution. (ii) X-ray crystallography determines the atomic structure of membrane proteins.

Q37 What is lipidomics and fluorescence recovery after photobleaching?

(i) **Lipidomics** — comprehensive analysis of lipids in the cell membrane using techniques like mass spectrometry. (ii) **FRAP** — studies mobility and dynamics of membrane proteins and lipids by bleaching a fluorescently labelled region with a laser and watching fluorescence recover as unbleached molecules move in.

Q38 What is glycocalyx?

The glycolipids and glycoproteins on the outside surface of the plasma membrane are called glycocalyx. It functions as cell-identification marks recognized by other cells.

Q39 What is cytosol?

(i) Cytosol is the aqueous ground substance of cytoplasm, containing various organelles and inclusions. (ii) It contains water in which many organic (proteins, carbohydrates, lipids) and inorganic salts are completely or partially dissolved.

Q40 Name major components of cell?

1. Plasma membrane 2. Cytoplasm 3. Nucleus.

Nucleus

Q41 What is nuclear lamina?

A protein lining on the inner side of the nuclear envelope. It binds to chromatin to give it structural support.

Q42 What are nuclear pores? Give their composition.

Tiny holes in the nuclear envelope. A nuclear pore is made of a nuclear pore complex with several subunits: annular, column, ring and luminal subunits.

Q43 Describe types of chromatin?

Euchromatin — genetically active chromatin involved in transcribing RNA to produce proteins. **Heterochromatin** — DNA that is genetically inactive.

Q44 What is NOR (nucleolus organizer region)?

Certain sites of chromosomes that form nucleoli. DNA found at NORs encodes the ribosomal RNA.

Q45 Why single nucleus undergo division to give NORs?

Cells that produce large amounts of protein need significant numbers of ribosomes, so the nucleolus is considerable in size. At the onset of mitosis the single nucleolus disappears, and after division a new nucleolus is formed from the NORs.

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Q46 Give components of nucleolus?

Granular and fibrillar components and DNA. The granular part consists of ribosomal subunits; the fibrillar part consists of raw materials of ribosome subunits.

Q47 What is length of DNA in human cell?

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

Q48 What is nucleus? Mention its two major functions.

A prominent nucleus is present in all eukaryotic cells (at centre in animal cells, pushed to the side in plant cells). It stores the cell's hereditary material (DNA) and coordinates the cell's activities, e.g. growth, protein synthesis and cell division.

Q49 Which materials can pass into and out of nucleus.

Building blocks of DNA and RNA and ATPs enter the nucleus. Ribosomal subunits built in nucleoli leave the nucleus and enter the cytoplasm.

Q50 What is nucleoplasm?

The semifluid matrix inside the nucleus. Within it, most nuclear material consists of chromatin, which organizes to form chromosomes during cell division.

Endoplasmic Reticulum and Ribosomes

Q51 What is the significance of membranous physical connection of nucleus with ER?

Due to their physical membranous connection, the lumen of the ER and the space between the layers of the nuclear envelope comprise a single compartment. This close association lets the ER and nucleus share information very efficiently.

Q52 Give functions of rough and smooth endoplasmic reticulum.

RER: production and processing of proteins.
SER: (i) production of lipids (ii) detoxification of drugs (iii) storing calcium, calcium and carbohydrate metabolism.

Q53 What are ribosomes? Where they are found?

Ribosomes are granular structures not bound by membrane. They are found in all organisms; in eukaryotes they may be attached to RER or scattered free in cytoplasm.

Q54 Where ribosomes are found other than cytoplasm?

Inside **mitochondria and chloroplasts**. These ribosomes differ in size and makeup from cytoplasmic ribosomes and are more like those of prokaryotes.

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Q55 Mention usage of proteins synthesized by ribosomes?

Proteins synthesized by free ribosomes are for the cell's own internal use, while proteins produced by ribosomes bound to RER are transported outside of the cell.

Q56 What is Svedberg value of complete ribosome?

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

Q57 What is Svedberg unit?

Ribosome subunits are described by their Svedberg values, based on their rate of sedimentation in a centrifuge. The complete eukaryotic ribosome is 80S; prokaryotic cells contain 70S ribosomes.

Mitochondria and Chloroplast

Q58 What do you know about origin of mitochondria?

According to scientists, millions of years ago small free-living prokaryotes were engulfed but not consumed by larger prokaryotes. The two developed a symbiotic relationship: the larger organism provided ample nutrients and the smaller one provided ATP molecules.

Q59 Write about occurrence of mitochondria.

The number of mitochondria depends on the metabolic requirements of the cell, ranging from one to thousands. They are found in nearly all eukaryotes (plants, animals, fungi, protists) and are large enough to be seen with a light microscope.

Q60 Why mitochondria are important for cell?

Mitochondria are the sites of cellular respiration; they generate ATP from oxygen and nutrients. ATP is the chemical energy "currency" that powers the cell's metabolic activities.

Q61 What are F-1 particles?

In mitochondria the inner surface of cristae has knob-like extensions into the matrix known as F-1 particles. These are actually the enzymes called **ATP-synthase**, where ATPs are synthesized.

Q62 Mention types of plastids?

Plastids are of three types: chloroplasts, chromoplasts and leucoplasts. Colourless **leucoplasts** are involved in storage; yellow-to-red **chromoplasts** give colours to plant parts; **chloroplasts** are green and carry out photosynthesis.

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Q63 Write the similarities and differences between mitochondria and chloroplast.

• Both convert energy for the cell, and both contain their own DNA and reproduce independently.
• **Mitochondria** perform aerobic respiration — they generate ATP by metabolizing sugars, fats and other fuels with oxygen.
• **Chloroplasts** perform photosynthesis — they convert energy from the sun into organic nutrients using carbon dioxide and water.

Q64 What are chloroplasts?

Specialized organelles that perform photosynthesis, in which light energy is converted into chemical energy. All green structures in plants contain chloroplasts, but most photosynthesis occurs in leaves.

Q65 What are thylakoids, grana and lamellae?

Thylakoids: disc-shaped compartments formed where inner membranes of the chloroplast fuse along their periphery.
Grana: stacks of thylakoids (singular granum), green due to chlorophyll.
Lamellae: non-green compartments that connect two grana.

Q66 What is stroma? What process glucose is formed in it?

Stroma is a semi-fluid inside the inner membrane of the chloroplast, containing dissolved enzymes; it comprises most of the chloroplast volume. ATPs produced in the light reaction are used in the stroma to transform low-energy CO_2 into high-energy compounds like glucose.

Golgi Apparatus and Lysosomes

Q67 What do you know about composition and occurrence of Golgi apparatus?

It consists of five to eight cup-shaped membrane-covered sacs (cisternae) stacked over each other. It is found in cells of plants, animals and unicellular eukaryotes.

Q68 How many cisternae are present in Golgi apparatus? Also give its location.

Golgi apparatus may consist of up to 60 cisternae (in some unicellular flagellates). Animal cells generally have 10–20 Golgi stacks, usually located close to the nucleus.

Q69 What are cis and trans faces of Golgi apparatus?

Each Golgi stack has two faces: the **cis face** near the endoplasmic reticulum and the **trans face** near the plasma membrane.

Q70 What do you know about the discovery of Golgi apparatus?

Discovered by **Camillo Golgi in 1898** during his research on the nervous system, using a new staining technique known as ‘Golgi staining’.

Q71 What is main function of Golgi apparatus?

It is the distribution and shipping department for the cell’s chemical products. It modifies proteins and lipids built in the ER and prepares them for export outside the cell or transport within the cell.

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Q72 How the compounds synthesized in ER are processed in Golgi apparatus?

Small vesicles containing proteins, carbohydrates, phospholipids etc. bud off from the ER, reach the cis face and fuse with it, releasing molecules into it. Enzymes in the Golgi lumen convert them into glycoproteins and glycolipids.

Q73 What happens to the processed products in Golgi apparatus?

They are released from the trans face in a vesicle and directed to their final destination inside or outside the cell. Exported products are called secretions; others return to the ER or become lysosomes.

Q74 Which additional substances are produced by Golgi apparatus in plant cells?

Pectin and other polysaccharides, essential for plant structure and metabolism.

Q75 What are lysosomes? Give their primary function.

Spherical organelles bounded by a single membrane that serve as digestive compartments. They break down cellular waste, fats, carbohydrates, proteins and other macromolecules into simple compounds for re-use.

Q76 In which type of cells are lysosomes most abundant and why?

In animals, in disease-fighting cells such as white blood cells, because WBCs must digest materials like bacteria, viruses and other foreign invaders.

Q77 How lysosomes help in autophagy?

Lysosomes break down the cellular materials that have exceeded their lifetime or are no longer needed by the cell.

Q78 How the cell remains safe from the digestive enzymes of a ruptured lysosomes?

The lysosomal matrix is acidic and the cytosol is neutral, so even if a lysosome ruptures, its digestive enzymes cannot work properly in the neutral cytosol, and the cell remains safe.

Q79 How many enzymes are present in lysosomes and where they are made?

Lysosomes have about **40 different hydrolytic enzymes**, manufactured in the endoplasmic reticulum and modified in the Golgi apparatus. The lysosome membrane protects the rest of the cell from their damage.

Q80 Define lysosomal storage diseases. Give examples.

In lysosomal storage diseases the patient lacks one of the hydrolytic enzymes of lysosomes. The abnormal lysosomes fill with indigestible substances which interfere with cellular functions, e.g. Pompe’s disease and Tay-Sachs disease.

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Q81 What is Pompe's disease?

A lysosomal storage disease in which the lysosome lacks a glycogen-digesting enzyme, so harmful amounts of glycogen accumulate in liver cells.

Q82 What is Tay-Sachs disease?

An essential lipid-digesting enzyme is missing; accumulation of lipids in nerve cells of the brain damages the nervous system, causing mental retardation and death in early childhood.

Q83 What role lysosomes play in development process?

Selective cell death is done by lysosomes during development, e.g. when a tadpole develops into a frog, the cells of the tail are destroyed by lysosomal enzymes (apoptosis).

Q84 How cell is not affected by enzymes of lysosomes?

Lysosomal enzymes require an acidic environment (pH about 4.8). The lysosomal matrix is acidic but the cytosol is neutral, so even if a lysosome ruptures, its enzymes become inactive and the cell remains uninjured.

Q85 How lysosomes were discovered?

In the mid-20th century, Belgian scientist **Christian de Duve** was studying carbohydrate metabolism in liver cells. He found that when cells were damaged in the centrifuge they released acid phosphatase, and suggested this digestive enzyme was enclosed in a membrane-bounded organelle, which he named the lysosome.

Q86 What role is played by lysosomes during brain development?

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

Peroxisomes, Glyoxysomes and Vacuoles

Q87 What are peroxisomes? Give their primary function.

Single-membrane-bound organelles found in all eukaryotic cells. They contain a variety of enzymes whose function is to rid the cell of toxic substances, e.g. hydrogen peroxide (a toxic by-product of metabolism) is broken down into water and oxygen.

Q88 What is function of catalase enzyme in peroxisome?

Catalase breaks down hydrogen peroxide, a common by-product of cellular metabolism, into water and oxygen:

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

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Q89 What is Zellweger syndrome?

A metabolic disorder caused by a defect in peroxisomes: their number is less or absent. It is congenital (present at birth) with no cure or effective treatment, causing early death.

Q90 What are glyoxysomes? Give their function.

Similar to peroxisomes but found only in plant cells. They contain enzymes that convert lipids into carbohydrates in cells of lipid-rich seeds (e.g. castor bean), providing energy to germinating seeds.

Q91 What are vacuoles? Give their important functions.

Membrane-bound sacs in cytoplasm. Functions: 1. In mature plant cells they provide structural support. 2. They serve in storage, waste disposal etc.

Q92 How large vacuole is formed in plant cells?

Many plant cells have a large single central vacuole, developed slowly by fusion of smaller vacuoles. It takes up 80% or more of the space in the cell.

Q93 Give role of central vacuole in plant cells.

It plays an important structural role by controlling **turgor pressure**, which makes the cell rigid and, along with the cell wall, maintains the structural integrity of the plant.

Q94 How is single large vacuole is formed?

Vacuoles are fluid-filled, single-membrane-bounded organelles. A young plant cell has many small vacuoles; when it matures, the small vacuoles fuse to form a single large vacuole.

Q95 What is importance of materials stored in vacuoles for humans?

Several materials commonly stored in plant vacuoles are useful for humans, such as opium, rubber and garlic flavouring.

Q96 Write role of vacuole other than turgor pressure.

1. Vacuoles store pigments that give certain flowers their colours, attracting bees and other pollinators. 2. They release molecules poisonous to insects and animals, discouraging them from consuming the plant.

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Centrioles, Cytoskeleton, Cilia and Flagella

Q97 What are centrioles. Give their composition and location in eukaryotic cells.

Hollow, cylindrical organelles associated with assembly and organization of cytoskeleton fibres (microtubules). A centriole is made of nine triplets of microtubules. In eukaryotic cells they occur in pairs at right angles to one another near the nuclear envelope.

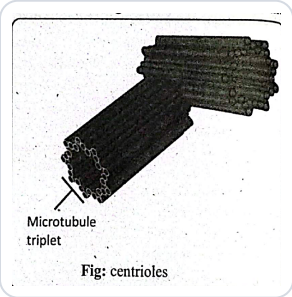


Fig: centrioles

Q98 What is basal body?

Each cilium and flagellum is anchored by a modified centriole known as the basal body.

Q99 How spindle fibres are formed in plants and fungi?

Cells of plants and fungi lack centrioles and basal bodies. Their microtubules and spindle fibres are organized from structures of the cytoplasm like MTOCs (microtubule-organizing centres).

Q100 Write function of centrioles?

In animal and protist cells centrioles are associated: 1. with assembly and organization of cytoskeleton fibres, i.e. microtubules 2. in the formation of cilia and flagella.

Q101 What is cytoskeleton? Give names of its types.

A network of protein fibres present in cytoplasm: microfilaments, microtubules and intermediate filaments.

Q102 What are microfilaments? Give their functions.

Solid rods made of a globular protein called actin. They help a dividing cell pinch off into two cells and, with myosin, help in muscle contraction.

Q103 What are microtubules? Give their function.

Straight, hollow cylinders of subunits made of tubulin proteins. 1. They are major components of cilia and flagella. 2. They form spindle fibres during cell division.

Q104 What are intermediate filaments? Give their functions.

Made of different proteins, commonly vimentin subunits. 1. They maintain cell shape and rigidity. 2. They anchor several organelles in the cell.

Q105 What are cilia and flagella? Give their function and difference.

Thin, tail-like projections extending from the cell body; their function is locomotory. Cilia are short and usually many; flagella are longer but less in number.

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Q106 What is axoneme? Give its structure.

The core of eukaryotic cilia and flagella. It contains two central microtubules surrounded by an outer ring of nine doublet microtubules; dynein bridges adjacent doublets. It is called the “9+2” structure.

Q107 Where cilia are present in humans? Write their function.

In the lining of the trachea, where they sweep mucus and dirt out of the breathing tubes.

Prokaryotic and Eukaryotic Cells

Q108 What is nucleoid?

A prokaryotic cell lacks a nucleus. Its DNA is present in a more or less central region known as the nucleoid (nucleus-like).

Q109 What is composition of cell wall of prokaryotic cell? Also write its location.

Surrounding the plasma membrane of most prokaryotic cells is a cell wall, which does not contain cellulose but peptidoglycan — a single large polymer of amino acids and sugar.

Q110 Compare size and cell division in eukaryotic and prokaryotic cells.

Size: 10–100 µm in eukaryotic and 1–10 µm in prokaryotic cells.
Cell division: eukaryotes show mitosis and meiosis; prokaryotes lack them and divide by direct division (binary fission).

Q111 Give similarities between prokaryotic and eukaryotic cells.

1. Both are made of cells (bacteria and archaea are prokaryotic; other forms eukaryotic). 2. Both have DNA as their genetic material. 3. Both have plasma membranes as coverings, and ribosomes for protein synthesis.

Cell Signalling

Q112 What is meant by cell signalling?

The ability of cells to respond to stimuli from their environment, producing cellular responses. It involves transmission of signals between cells through a series of molecular events leading to a cellular response.

Q113 Differentiate between cell signalling and signal transduction.

In cell signalling, a signal molecule binds to a receptor on the membrane of a target cell, while in signal transduction the intracellular signalling pathway is activated as a result of this binding.

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Q114 What is effect of signal transduction pathway?

It leads to changes in gene expression, i.e. turning specific genes on or off, resulting in cellular responses like cell growth, division, differentiation or apoptosis.

Q115 What is difference between protein/peptide signalling and steroid signalling?

Protein/peptide signalling molecules are water-soluble and can't pass through the plasma membrane, so they bind to a receptor on the membrane, activating an intracellular pathway. In steroid signalling, the hormone diffuses through the plasma membrane and acts inside, affecting protein production.

Membrane Transport Mechanisms

Q116 Differentiate between diffusion and facilitated diffusion.

Diffusion: net movement of a substance from higher to lower concentration without using energy.
Facilitated diffusion: molecules are taken in or out with the help of transport proteins in the plasma membrane; no energy is used.

Q117 What are main types of transport proteins?

1. **Channel proteins** — hydrophilic channels allowing specific molecules to pass, e.g. ion channels. 2. **Carrier proteins** — bind the specific molecule, change conformation and move it across, e.g. glucose transporters.

Q118 What is reverse osmosis?

A process in which external pressure is applied to push water through a semipermeable membrane from a high-solute to a low-solute concentration.

Q119 What is Na^+-K^+ pump? Where it is located?

1. It is composed of carrier proteins for active transport. 2. It actively moves Na^+ to the outside and K^+ to the inside of the cell. 3. It is located in the membranes of nerve cells.

Q120 Differentiate between phagocytosis and pinocytosis?

Phagocytosis: intake of solid material during endocytosis. **Pinocytosis:** intake of liquids during endocytosis.

Q121 Differentiate between endocytosis and exocytosis?

Endocytosis: bulky materials are moved into the cell by invagination of the plasma membrane, forming a vesicle.
Exocytosis: bulky material is exported; the vesicle fuses with the plasma membrane from inside and releases its contents outside.

Q122 What is role of plasma membrane during exchange of matter?

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

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Q123 What is membrane transport mechanism, its importance and types?

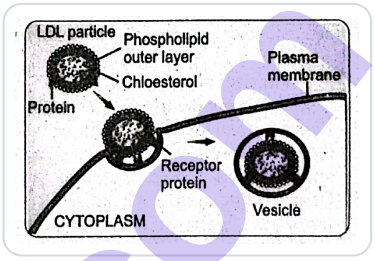
Movement of substances in and out of cells, crucial for nutrient uptake, waste elimination, gas exchange and signal transduction. It lets the cell maintain homeostasis, acquire nutrients, remove wastes and communicate. Two types: **passive transport** (no energy) and **active transport** (uses energy).

Q124 What is meant by tonicity?

The relative concentration of solutes in solutions. **Hypertonic** solutions have more solute, **hypotonic** less, and **isotonic** solutions have equal solute concentrations.

Q125 What is receptor-mediated endocytosis?

Specific receptor proteins of the plasma membrane pick up material from outside and pinch inside to form a vesicle. E.g. liver cells have receptor proteins for cholesterol, which circulates in blood as low-density lipoproteins (LDLs); they recognize and take up LDLs.



Stem Cells

Q126 What are stem cells?

Unique cells with the remarkable ability to divide and develop into many different cell types in the body.

Q127 Difference between totipotent and pluripotent stem cells?

Totipotent: can differentiate into all possible cell types, e.g. zygote. **Pluripotent:** can turn into almost any cell, e.g. cells of the early embryo.

Q128 Differentiate between multipotent and oligopotent stem cells.

Multipotent: differentiate into a closely related family of cells, e.g. haematopoietic stem cells become RBCs, WBCs or platelets. **Oligopotent:** differentiate into a few cell types, e.g. adult lymphoid or myeloid stem cells.

Q129 What are unipotent stem cells?

They produce cells of one kind only, their own type, e.g. adult muscle stem cells.

Q130 Describe the uses of stem cells.

1. Regenerative medicine 2. Drug testing and development 3. Personalized medicine.

Q131 What are embryonic stem cells?

Derived from the inner cell mass of blastocysts (early-stage embryo). They are pluripotent.

Q132 What are adult stem cells?

Stem cells found in various tissues throughout the body, such as bone marrow, fat and blood.

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Q133 What are induced pluripotent stem cells?

Generated in the lab by reprogramming adult somatic cells to a pluripotent state; similar to embryonic stem cells.

Q134 Give advantage and disadvantage of induced pluripotent stem cells?

Advantage: no ethical issues linked to embryonic stem cells. **Disadvantage:** reprogramming can introduce genetic changes that may lead to tumours.

Q135 What are plasmodesmata?

Small channels that directly connect the cytoplasm of neighbouring plant cells, penetrating both primary and secondary walls. They let certain molecules pass between cells, so are important in cellular communication.

Q136 Discuss various uses of stem cells?

1. **Regenerative medicine:** repair or replace damaged tissues — spinal cord injuries, type 1 diabetes, Parkinson's disease, heart disease. 2. **Drug testing and development:** disease models for accurate drug testing, reducing reliance on animal models. 3. **Personalized medicine:** cells from a patient's own cells reduce immune rejection.

Q137 What is importance of ability to distinguish among different cell?

It is crucial to life: it allows cells in an embryo to sort themselves into tissues and organs, and helps the immune system recognize and reject foreign cells, e.g. infectious bacteria.

Q138 Compare protein, lipid and carbohydrate content of different membranes.

Membrane	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

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PART C

Multiple Choice Questions

Exercise MCQs

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 double-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

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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 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

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 — Exercise MCQs

1	c	2	d	3	b	4	a	5	c	6	d
7	b	8	a	9	b	10	d	11	d	12	b

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Note on the answer key

Q8: the notes' key gives (b), but digesting macromolecules with hydrolytic enzymes is the job of **lysosomes**; peroxisomes break down fatty acids and amino acids by oxidation, so the answer is **(a)**. **Q79:** the notes' key gives (a) totipotent; a cell that can become *almost* any cell is **pluripotent (c)** — totipotent cells form *all* cell types (see Q80). All other answers follow the notes' key.

SLO-Based Multiple Choice Questions

Cell Theory

13 **Who concluded that parts of plants were made of compartments?**

(a) Robert Hooke
(b) Robert Whittaker
(c) Louis Pasteur
(d) Leeuwenhoek

14 **Nucleus was discovered by:**

(a) Robert Koch
(b) Louis Pasteur
(c) Theodor Schwann
(d) Robert Brown

15 **Which of the following is exception to cell theory?**

(a) Bacteria
(b) Fungi
(c) Virus
(d) Algae

Microscopy

16 **Ability to enlarge the image of an object is called:**

(a) Resolution
(b) Magnification
(c) Extension
(d) Expansion

17 **Ability to distinguish between two points are close together on an object is:**

(a) Staining
(b) Magnification
(c) Resolution
(d) Division

18 **Resolution of light microscope is:**

(a) 0.2 micrometer
(b) 0.2 millimeter
(c) 0.2 nanometer
(d) 0.2 millimeter

19 **Resolution of electron microscope is:**

(a) 0.2 nanometer
(b) 0.2 micrometer
(c) 0.2 centimeter
(d) 0.2 centimeter

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Structure of Cell

20 ***Yeast* and *Euglena* are:**

(a) Unicellular eukaryotes
(b) Multicellular eukaryotes
(c) Non-cellular prokaryotes
(d) Unicellular prokaryotes

21 **Actual cell wall of cell is:**

(a) Secondary wall
(b) Primary wall
(c) Middle lamella
(d) Tertiary wall

22 **The small channel that directly connect cytoplasm of neighbouring plant cells to each other are:**

(a) Plasmodesmata
(b) Stomata
(c) Golgi apparatus
(d) Vacuole

23 **According to fluid mosaic model proteins are:**

(a) Present outside lipid bilayer
(b) Present towards innerside of lipid bilayer
(c) Float in the lipid bilayer
(d) Not present in the cell membrane

24 **The glycoprotein and glycolipids on outside surface of plasma membrane are collectively called as:**

(a) Phospholipoid
(b) Glycocalyx
(c) Phosphoproteins
(d) Lipoproteins

25 **Scanning electron microscopy is useful for examining:**

(a) Internal structure
(b) Internal function of cell
(c) Surface topology of cell
(d) Signal transmission of cell

26 **X-ray crystallography is used to study:**

(a) Surface topology of cell
(b) Create sharp and detail images
(c) Atomic structure of membrane proteins
(d) High resolution image of membrane

27 **Three major components i.e. plasma membrane, cytoplasm and nucleus make up:**

(a) Tissue
(b) Organ
(c) Organelle
(d) Cell

28 **Organelles are generally enclosed by a membrane except:**

(a) Ribosomes
(b) Lysosomes
(c) Peroxisomes
(d) Glyoxisomes

29 **The semifluid matrix found inside the nucleus is called:**

(a) Nucleolus
(b) Chromosomes
(c) Nucleoplasm
(d) Cytoplasm

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30 **Nuclear lamina on the innerside of a nuclear envelope is:**

(a) Protein
(b) Lipid
(c) Vitamin
(d) Nucleotide

31 **Which one is not related to the nuclear pore?**

(a) Annular subunit
(b) Column subunit
(c) Ribosomal subunit
(d) Lumenal subunit

32 **Nucleoli are formed at certain sites called nucleolar organizer regions found on:**

(a) Chromosomes
(b) Nuclear membrane
(c) Nuclear pores
(d) Nucleoplasm

33 **Granular components of nucleolus consist of:**

(a) DNA molecules
(b) Ribosomal subunits
(c) Centriolar subunits
(d) Nucleolar subunits

34 **A chromosome is made of chromatids and:**

(a) Centromere
(b) Centrioles
(c) Microfilaments
(d) Microtubules

35 **Surface of rough endoplasmic reticulum is covered with:**

(a) Centrioles
(b) Nucleolus
(c) Ribosomes
(d) Nucleosome

36 **Detoxification of harmful drug is function of:**

(a) Smooth endoplasmic reticulum
(b) Rough endoplasmic reticulum
(c) Cristae of mitochondria
(d) Thylakoid of chloroplast

37 **Protein production machinery is:**

(a) Lysosomes
(b) Ribosomes
(c) Glyoxisomes
(d) Mitochondria

38 **Eukaryotic ribosomes are produced and assembled in:**

(a) Cytoplasm
(b) Nucleolus
(c) Plastids
(d) Golgi apparatus

39 **Which RNA is required for protein synthesis?**

(a) Ribosomal RNA
(b) Messenger RNA
(c) Transfer RNA
(d) All of these

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40 **Svedberg values are for which protein:**

(a) Sedimentation
(b) Orientation
(c) Augmentation
(d) Fertilization

41 **Which is not true for eukaryotic ribosomes?**

(a) They are involved in protein synthesis
(b) They are produced in nucleolus
(c) They have Svedberg value of 70S
(d) They are composed of two subunits

42 **F-1 particles on inner membrane of mitochondria are enzymes:**

(a) ATP reductase
(b) ATP synthase
(c) Matrix catalase
(d) Protein synthase

43 **Mitochondria is bounded by how many membranes:**

(a) 1
(b) 2
(c) 3
(d) 4

44 **Sites for cellular respiration are:**

(a) Lungs
(b) Mitochondria
(c) Ribosomes
(d) Polysome

45 **ATP is a form of which energy:**

(a) Physical
(b) Electrical
(c) Chemical
(d) Analytical

46 **Semifluid present inside the inner membrane space of chloroplast is called:**

(a) Stroma
(b) Matrix
(c) Lumen
(d) Thylakoid

47 **Non-green compartments of chloroplast are:**

(a) Leucoplast
(b) Grana
(c) Lamellae
(d) Thylakoids

48 **Which is common factor among mitochondria and chloroplast:**

(a) Both have chlorophyll
(b) Both have dark reactions
(c) Both have DNA
(d) Both have centrioles

49 **Which organelle is involved in the processing of proteins, carbohydrates and phospholipids prepared in the cell:**

(a) Endoplasmic reticulum
(b) Ribosomes
(c) Golgi apparatus
(d) Leucoplast

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50 **In Pompe's disease lysosome lacks:**

(a) Glycogen-digesting enzymes
(b) Lipids digesting enzymes
(c) Proteins digesting enzymes
(d) Glucose digesting enzymes

51 **In Tay-Sachs disease an essential enzyme is missing which digests:**

(a) Protein
(b) Starch
(c) Lipids
(d) Vitamins

52 **Which of the following is single membrane bound organelle:**

(a) Peroxisome
(b) Mitochondria
(c) Golgi apparatus
(d) Nucleus

53 **Zellweger syndrome is due to defect in:**

(a) Lysosome
(b) Ribosome
(c) Peroxisome
(d) Glyoxisome

54 **The organelle found only in plants is:**

(a) Glyoxisomes
(b) Lysosomes
(c) Ribosomes
(d) Polysomes

55 **During germination glyoxisomes convert stored lipid into:**

(a) Carbohydrates
(b) Fats
(c) Proteins
(d) Vitamins

56 **Membrane of vacuole is called:**

(a) Leucoplast
(b) Tonoplast
(c) Chromoplast
(d) Vacuoloplast

57 **What is not true for centrioles:**

(a) Found in plants
(b) Found in protist
(c) Occur in pairs
(d) Located at right angle to each other

58 **Major components of cilia and flagella are:**

(a) Intermediate filament
(b) Microtubules
(c) Microfilaments
(d) Action filaments

59 **Cilia and flagella are:**

(a) Locomotory organs
(b) Excretory organ
(c) Sense organs
(d) Reproductive organ

60 **The core of eukaryotic cilia and flagella is called:**

(a) Axoneme
(b) Myomere
(c) Acrorere
(d) Telomere

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61 **Basal body is present at the base of:**

(a) Chromosomes
(b) Cilia
(c) Golgi vesicles
(d) Liposomes

62 **Prokaryotic flagella is built from the protein:**

(a) Pillin
(b) Flagellin
(c) Actin
(d) Myosin

63 **Genetic material of both prokaryotic and eukaryotic cell is made of:**

(a) DNA
(b) RNA
(c) Protein
(d) Carbohydrate

64 **Nucleoid is analogous structure to:**

(a) Chromosomes
(b) Nucleus
(c) Chromatid
(d) Nucleolus

65 **Sedimentation rate of complete ribosome of a prokaryote is:**

(a) 50S
(b) 60S
(c) 70S
(d) 80S

66 **What is not true for prokaryotes:**

(a) They divide by binary fission
(b) Mitosis and meiosis is present in them
(c) Their ribosomes is of 70S
(d) Have cell wall of peptidoglycan

Cell Signalling

67 **Receptor on the membrane of target cell for signal reception is:**

(a) Protein
(b) Lipid
(c) Nucleotide
(d) Phospholipid

68 **Which molecule can act as second messenger during signal transmission:**

(a) Cyclic AMP
(b) Calcium ions
(c) Inositol triphosphate
(d) All of these

69 **Cell signaling pathways involve the transmissions of signals:**

(a) From cell’s exterior to interior
(b) From cell’s interior to exterior
(c) From one cell to nearby cells
(d) From one cell to distant cells

70 **Protein or peptide signalling molecules can’t pass through plasma membrane because:**

(a) They are large
(b) They are neutral
(c) They are soluble in water
(d) They are insoluble in water

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71 **Membrane transport mechanisms are essential processes that enable cell:**

(a) To maintain homeostasis
(b) Acquire nutrient
(c) Excretion
(d) All of these

Membrane Transport Mechanism

72 **What is not true for facilitated diffusion:**

(a) It involves transport-proteins
(b) It is from high concentration to low
(c) Energy is used in it
(d) It is passive transport

73 **Which is true for channel proteins:**

(a) They are hydrophilic
(b) They are hydrophobic
(c) They are fatty in nature
(d) They don't allow passage of specific ions

74 **Aquaporin allows rapid transport of:**

(a) Water
(b) Oil
(c) Acid
(d) Base

75 **Which process is used for purification of water:**

(a) Osmosis
(b) Reverse osmosis
(c) Diffusion
(d) Reverse diffusion

76 **The membranes of nerve cells have carrier proteins in the form of:**

(a) Na^{+}–K^{+} pump
(b) Na^{+}–Cl^{-} pump
(c) Ca^{2+}–Mg^{2+} pump
(d) Na^{+}–S^{+} pump

77 **Intake of solid material is called:**

(a) Phagocytosis
(b) Pinocytosis
(c) Cytokinesis
(d) Karyokinesis

78 **Cholesterol circulates in our blood as:**

(a) HDL
(b) LDL
(c) VHHL
(d) VLDL

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Stem Cells

79 **Which stem cell can differentiate into almost any cell:**

(a) Totipotent
(b) Multipotent
(c) Pluripotent
(d) Unipotent

80 **Totipotent cell can differentiate into:**

(a) All possible cell types
(b) Almost any cell
(c) Few different types of cells
(d) One kind of cell

81 **Adult muscle stem cells one example of:**

(a) Totipotent
(b) Pluripotent
(c) Algopotent
(d) Unipotent

82 **Hematopoietic stem cells one example of:**

(a) Totipotent
(b) Multipotent
(c) Oligopotent
(d) Pluripotent

83 **Uses of stem cell include:**

(a) Regenerative medicine
(b) Drug testing
(c) Personalized medicine
(d) All of these

84 **Inner cell mass of blastocysts are:**

(a) Embryonic stem cell
(b) Adult stem cell
(c) Induced pluripotent stem cell
(d) Unipotent stem cell

85 **Which of the following has ethical controversies?**

(a) Induced pluripotent stem cells
(b) Embryonic stem cell
(c) Adult stem cell
(d) Unipotent stem cell

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Answer Key — SLO-Based MCQs (13-85)

13	a	14	d	15	c	16	b	17	c	18	a	19	a	20	a	21	b
22	a	23	c	24	b	25	c	26	c	27	d	28	a	29	c	30	a
31	c	32	a	33	b	34	a	35	c	36	a	37	b	38	b	39	d
40	a	41	c	42	b	43	b	44	b	45	c	46	a	47	a	48	c
49	c	50	a	51	c	52	a	53	c	54	a	55	a	56	b	57	a
58	b	59	a	60	a	61	b	62	b	63	a	64	b	65	c	66	b
67	a	68	d	69	a	70	c	71	d	72	c	73	a	74	a	75	b
76	a	77	a	78	b	79	c	80	a	81	d	82	b	83	d	84	a
85	b																

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PART D

Solved Exercise

Exercise Long Questions

Q1 **Write details of the structure and the chemical composition of cell walls of eukaryotes and prokaryotes.**

See **Long Question Q6, Q8 and Q25**.

Q2 **Explain the chemical composition and the functions of plasma membrane.**

See **Long Question Q9 and Q10**.

Q3 **Identify the role of glycolipids and glycoproteins as the cell surface makers.**

See **Long Question Q9 (glycocalyx)**.

Q4 **Explain the structure, chemical composition and function of ribosomes.**

See **Long Question Q15**.

Q5 **Explain the structure, and functions of Golgi complex.**

See **Long Question Q18**.

Q6 **Describe the structure, chemical composition and function of chromosome.**

See **Long Question Q13 (f)**.

Q10 **Explain the role of lysosomes and peroxisomes in regulating the amounts of cellular contents.**

See **Long Question Q19 and Q20**.

Q11 **Describe the structures of the three fibres that make the cytoskeleton.**

See **Long Question Q23**.

Q12 **Describe the formation and functions of lysosomes.**

See **Long Question Q19 (and Q18 for budding from Golgi)**.

Q13 **Compare mitochondria and chloroplasts as the organelles that are involved in cellular energetics.**

See **Long Question Q16 and Q17**.

Q14 **Describe the basic structure of mitochondrion, from outside inward.**

See **Long Question Q16**.

Q15 **Describe the pathway of protein signal and steroid signal from outside of a cell to inside.**

See **Long Question Q28**.

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Q7 **Discuss nuclear envelope and nuclear pore complex in detail.**

See **Long Question Q13 (b–d)**.

Q8 **Explain how Golgi apparatus is involved in making cell secretions.**

See **Long Question Q18**.

Q9 **Describe the structure and functions of smooth and rough endoplasmic reticulum.**

See **Long Question Q14**.

Q16 **Categorize and explain different types of stem cells.**

See **Long Question Q33 and Q35**.

Q17 **What are the advantages and disadvantages of using induced pluripotent stem cells?**

See **Long Question Q35**.

Inquisitive Questions

Q1 **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?**

The cell is physiologically very active in **secretion**, e.g. pancreatic cells that produce digestive enzymes have a large Golgi apparatus.

Q2 **If a signalling molecule is lipid-soluble, like a steroid hormone, what is the most likely mechanism for its action within the target cell?**

After entering the target cell it binds to specific **intracellular receptors**. This forms an active receptor–hormone complex which moves into the nucleus and binds to specific DNA sequences to regulate the transcription of genes.

Q3 **Why do we categorize endocytosis and exocytosis as active transport?**

In endocytosis the bulky material moves into the cell; this requires energy to form the vesicle and pinch it off from the cell membrane. Similarly, in exocytosis the material moves out of the cell, which also requires energy for fusion of the vesicle with the membrane.

Q4 **Justify why the membrane may be described as fluid.**

Because the molecules making up the plasma membrane (phospholipids and proteins) can **move around each other freely**. This makes the structure of the plasma membrane flexible and constantly changing in shape.

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