Unit- I
(Cell Biology)

Part – A

Short answer type questions :

1. Define Prokaryotic Cells.
Ans: Prokaryotic cells lack a nucleus and other membrane-bound organelles.
Example: Bacteria and Archaea.

2. Define Eukaryotic Cell.
Ans: Eukaryotic cells have a nucleus in which the genetic material is separated from the cytoplasm.

3. Define Nucleolar Organizing Centre.
Ans: A chromosomal region that contains ribosomal RNA (rRNA) genes and is essential for the formation of the nucleolus.

4. Define SER and RER.
Ans: **SER (Smooth Endoplasmic Reticulum):**
Involved in lipid synthesis.
RER (Rough Endoplasmic Reticulum):
Has ribosomes attached and is involved in protein synthesis.

5. Define Microfilaments.
Ans: Also called actin filaments, microfilaments play a vital role in contracting molecular motors driven by actomyosin.

6. Define Microtubules.
Ans: Microtubules are the largest structures in the cytoskeleton and facilitate cell movement, cell division, and the transportation of materials within the cell.

7. Define Intermediate Filaments.
Ans: Intermediate filaments are cytoskeletal structural components found in the cells of vertebrates and many invertebrates.

8. Write Down Two Functions of the Golgi Apparatus.
An. (a) Transport proteins and lipids.
(b) Modify proteins and lipids.

9. Define Mesosomes.
Ans: Mesosomes are invaginations of the plasma membrane in prokaryotes like bacteria and are involved in respiration in these organisms.

10. Write Down Two Functions of the ER.
Ans. **(a)** Triggers protein synthesis (RER).

(b) Triggers lipid synthesis (SER).

11. Write down the name of Semi-autonomous organelles.
Ans. Semi-autonomous organelles include **mitochondria** and **chloroplasts**.

12. Define the Tonoplast membrane.
Ans. The tonoplast is the membrane surrounding the central vacuole in plant cells, regulating the

movement of ions, water, and small molecules into and out of the vacuole.

13. Define cristae.
Ans. Cristae are the folds in the inner membrane of mitochondria, increasing surface area for energy production through oxidative phosphorylation.

14. Define matrix in mitochondria.
Ans. The matrix is the innermost compartment of the mitochondrion, containing enzymes for the Krebs cycle, DNA, and ribosomes.

15. Write two main functions of lysosomes.
Ans. 1. Lysosomes break down waste materials and cellular debris.
2. They digest foreign materials like bacteria that are engulfed by the cell.

16. Write two main functions of Peroxisomes.
Ans. 1. Peroxisomes detoxify harmful substances.
2. They break down fatty acids through oxidation.

17. Who discovered the nucleolus?
Ans. The nucleolus was discovered by **Felix Dujardin** in 1835.

18. Write down two differences between prokaryotic and eukaryotic cells.
Ans. 1. **Prokaryotic cells**: Lack a nucleus and membrane-bound organelles.
2. Eukaryotic cells: Have a defined nucleus and membrane-bound organelles.

19. Write two main functions of mitochondria.
Ans. 1. Mitochondria generate ATP through cellular respiration.
2. They also regulate cell death (apoptosis) and store calcium.

20. Write the chemical composition of the Cell Wall.
Ans. The chemical composition of the cell wall in plants is primarily **cellulose**, while in fungi, it is composed of **chitin**, and in bacteria, it contains **peptidoglycan**.

21. Define the nuclear pore complex.
Ans. The nuclear pore complex is a protein structure in the nuclear envelope that regulates the passage of molecules between the nucleus and the cytoplasm.

22. What is protein glycosylation?
Ans. Protein glycosylation is the process of adding carbohydrate (sugar) molecules to a protein, which is crucial for protein folding, stability, and function.

23. What is protein sorting?
Ans. Protein sorting is the process by which proteins are directed to their correct cellular destinations,

such as the nucleus, mitochondria, or cell membrane.

24. What is protein targeting?

Ans. Protein targeting refers to the process by which proteins are directed to specific locations within the cell, based on signals in their amino acid sequences.

25. Who discovered the nucleus?

Ans. The nucleus was discovered by **Robert Brown** in 1831.

26. Write down two differences between Euchromatin and Heterochromatin.

Ans. **1. Euchromatin**: Loosely packed, active in gene expression.
2. Heterochromatin: Tightly packed, inactive in gene expression.

27. Write down two differences between active and passive transport.

Ans. 1. **Active transport**: Requires energy (ATP) to move molecules against their concentration gradient.
2. Passive transport: Does not require energy and moves molecules along their concentration gradient.

28. Define Endocytosis.

Ans. Endocytosis is the process by which cells engulf external substances by wrapping the plasma membrane around them to form a vesicle.

29. Define Exocytosis.

Ans. Exocytosis is the process by which cells expel substances by vesicles fusing with the plasma membrane to release contents outside the cell.

30. Write down the various enzymes present in the mitochondria.

Ans. Some enzymes present in mitochondria include **ATP synthase**, **citrate synthase**, **cytochrome c oxidase**, and various enzymes involved in the Krebs cycle and oxidative phosphorylation.

Part – B

Long answer type questions :

1. Describe the Characteristics of Prokaryotic and Eukaryotic Cells in Detail.

Ans.

Feature	Prokaryotic Cell	Eukaryotic Cell
Nuclear Membrane	Absent	Present
Chromosomes	Single	DNA combined with histone proteins
DNA Structure	Naked	DNA surrounded by a nuclear membrane
Nucleolus	Absent	Present
Mitochondria	Absent; respiratory enzymes in plasma membrane	Present in cytoplasm; respiratory organelles
Ribosomes	70s type (50s and 30s subunits); all free in the cytoplasm	80s type (60s and 40s subunits); some attached to the endoplasmic reticulum, others free
Chloroplasts	Absent, except in blue-green algae	Present in plants and algae
Golgi Bodies	Absent	Present
Lysosomes	Absent	Present
Cell Wall	Thin, non-cellulosic, contains amino sugars and muramic acid	Thick, cellulosic, no amino sugars or muramic acid
Cytoplasmic Streaming/Amoeboid Movement	Does not occur	Occurs
Cell Division	Binary fission	Mitosis and meiosis
Mesosomes	Present	Absent

2. Describe Membrane Transport in Detail.

Ans. Membrane Transport:

Membrane transport is the process of moving water and solutes across the cell membrane, which is a lipid bilayer. It is essential for cellular life because it helps cells maintain a constant internal composition and exchange matter and energy with their environment.

1. **Active Transport:**

When a substance moves across the cell membrane against its concentration or electrical gradient with the expenditure of energy, it is called active transport. The energy is obtained from the breakdown of high-energy compounds like ATP. Active transport is classified into primary and secondary types based on the energy source.

- **Primary Active Transport:**
  In primary active transport, energy is derived directly from the breakdown of ATP, and the carrier protein involved is called a pump. The enzymes that catalyze the hydrolysis of ATP are called ATPases.

- **Example:**
  Sodium-Potassium Pumps (Na+/K+ ATPases):
  Location: Found in most cells, especially excitable cells.
  Structure: Consists of two subunits, α and β.
  Functions: Controls cell volume and maintains resting membrane potential.
- **Hydrogen-Potassium ATPases:**
  Location: Found in gastric glands of the stomach and distal convoluted tubules of the nephron.
  Function: Transports hydrogen ions in parietal cells of the gastric glands.
- **Secondary Active Transport:**
  Involves the movement of substances against their concentration gradient by utilizing the energy stored in ion gradients, primarily sodium. This energy is used to transport other substances like glucose and amino acids.

2. Passive Transport:

Passive transport is the movement of substances from an area of higher concentration to lower concentration without the expenditure of energy.

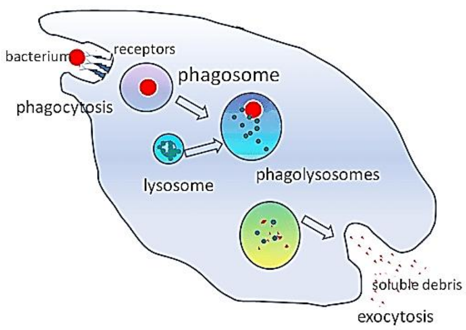
- **Simple Diffusion:** No carrier is required.
- **Facilitated Diffusion:** Also called carrier-mediated diffusion, where large or charged molecules require a carrier protein to facilitate transport.

3. Vesicular Transport:

- **Endocytosis:** Materials to be engulfed come into contact with the cell membrane, which invaginates and pinches off to form a vesicle inside the cell.

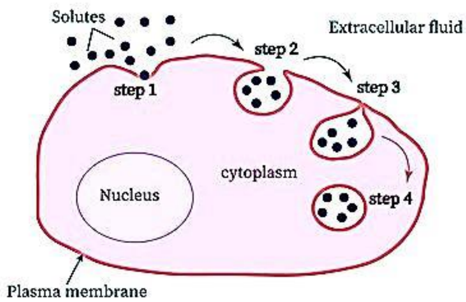
4. Phagocytosis and Pinocytosis

- **Phagocytosis:** If the material is solid, it's called "cell eating."



Phagocytosis

- **Pinocytosis:** If the material is a liquid, it's called "cell drinking."



- **Exocytosis:** The reverse of pinocytosis, where substances synthesized within secretory cells are secreted out of the cell.

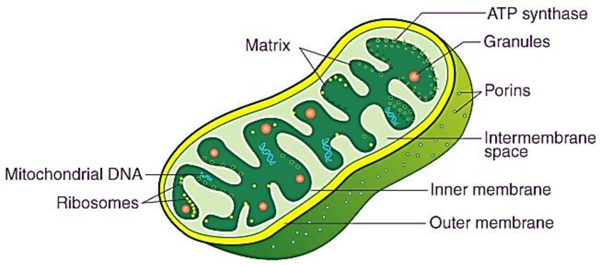
3. Write Short Notes on Structure and function of the Mitochondria.

Ans. Mitochondria are membrane-bound organelles found in the cytoplasm of eukaryotic cells, often referred to as the **"powerhouses"** of the cell because they produce the majority of the cell's energy in the form of **adenosine triphosphate (ATP)**. Mitochondria play a key role in cellular respiration, energy production, and various metabolic processes.

Structure of Mitochondria

Mitochondria are unique in that they have a double membrane structure:

1. **Outer Membrane:**
   - The outer membrane is smooth and acts as a barrier between the mitochondrion and the cytoplasm.
   - It is permeable to small molecules and ions due to the presence of **porin proteins**, which allow substances to pass through freely.
   - The outer membrane also contains receptors and enzymes involved in lipid metabolism.
2. **Inner Membrane:**
   - The inner membrane is highly folded to form **cristae** (the folds or ridges), which significantly increase its surface area.
   - This membrane is impermeable to most ions and molecules, creating a distinct environment inside the mitochondrion.
   - The inner membrane contains important enzymes for **oxidative phosphorylation**, including the **electron transport chain (ETC)** and **ATP synthase**.
   - The inner membrane also contains **ATP transporters** to shuttle ATP out of the mitochondria to the cytoplasm.
3. **Intermembrane Space:**
   - The space between the inner and outer membranes is called the **intermembrane space**.
   - It plays a role in energy production, as protons (H+) are pumped into this space during cellular respiration, creating a proton gradient that drives ATP synthesis.
4. **Matrix:**
   - The **matrix** is the innermost compartment of the mitochondrion, enclosed by the inner membrane.
   - It contains enzymes that catalyze reactions for the **Krebs cycle** (also called the citric acid cycle or tricarboxylic acid cycle), a key step in cellular respiration.
   - The matrix also contains **mitochondrial DNA (mtDNA)**, **ribosomes**, and other molecules required for protein synthesis within the mitochondria.



Function of Mitochondria :

1. **ATP Production (Cellular Respiration):**
   - Mitochondria are primarily responsible for the production of **ATP** through a process called **oxidative phosphorylation**.
   - In this process, glucose and fatty acids are broken down to produce ATP, carbon dioxide, and water. The main stages of ATP production are:
   - **Glycolysis** (occurs in the cytoplasm): Glucose is broken down into pyruvate, producing a small amount of ATP.
   - **Pyruvate Decarboxylation** (in mitochondria): Pyruvate is converted into acetyl-CoA, which enters the Krebs cycle.
   - **Krebs Cycle** (Citric Acid Cycle): Acetyl-CoA is oxidized to produce high-energy electrons (NADH, FADH2) and a small amount of ATP.
   - **Electron Transport Chain (ETC)**: High-energy electrons are transferred through protein complexes embedded in the inner mitochondrial membrane. This creates a proton gradient across the inner membrane.
   - **ATP Synthase**: The protons flow back into the matrix through **ATP synthase**, driving the production of ATP from ADP and inorganic phosphate.
2. **Regulation of Cellular Metabolism:**
   - Mitochondria are involved in regulating the cell's metabolism, including the synthesis of various biomolecules like **lipids**, **steroids**, and certain **amino acids**.
   - They also participate in the metabolism of pyruvate, fatty acids, and amino acids.
3. **Calcium Homeostasis:**
   - Mitochondria play a key role in maintaining **calcium balance** within the cell. They can store calcium ions and release them as needed, helping to regulate cellular processes like muscle contraction and enzyme activity.
4. **Apoptosis (Programmed Cell Death):**
   - Mitochondria are involved in the regulation of **apoptosis** (programmed cell death), a controlled process that removes damaged or unnecessary cells.
   - Mitochondrial proteins like **cytochrome c** are released into the cytoplasm during apoptosis, triggering the activation of caspases (proteases that mediate cell death).
5. **Heat Production (Thermogenesis):**
   - In specialized cells, like brown adipose tissue, mitochondria can generate heat instead of ATP in a process known as **thermogenesis**. This process is vital for regulating body temperature in some organisms.

4. Write Short Notes on Structure and function of the Chloroplast.

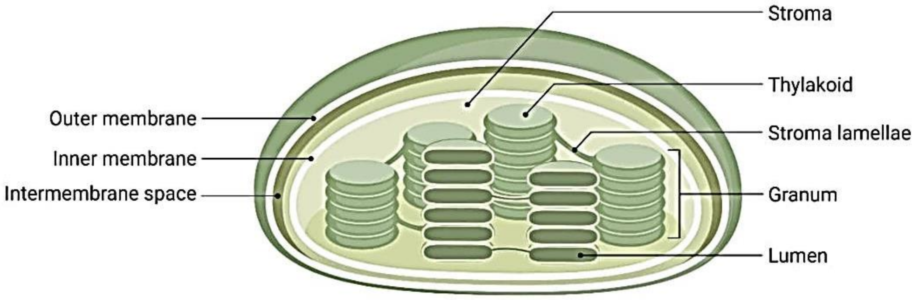
Ans. Chloroplasts have a complex, double-membrane structure, and they contain several key components that are important for their function in photosynthesis.

Ultra Structure of Chloroplast :

1. **Outer Membrane:**
   - The outer membrane of the chloroplast is smooth and permeable to small molecules such as **ions**, **metabolites**, and **water**. This membrane allows the free passage of ions and other small molecules between the cytoplasm and the intermembrane space of the chloroplast.
2. **Inner Membrane:**
   - The inner membrane lies just beneath the outer membrane and is **impermeable** to most ions and molecules, providing a selective barrier.

- The inner membrane contains transport proteins that regulate the movement of metabolites and ions into and out of the chloroplast.

3. **Stroma:**
    - The **stroma** is a dense, colorless liquid found inside the inner membrane. It is analogous to the cytoplasm in the cell.
    - The stroma contains enzymes, **ribosomes**, **DNA**, and **RNA**, and is the site where the **Calvin cycle** (the second stage of photosynthesis) takes place.
    - The stroma also contains **plastidial DNA**, which is responsible for producing some of the chloroplast's proteins, although most chloroplast proteins are encoded by nuclear DNA.
4. **Thylakoid Membranes:**
    - The **thylakoids** are membrane-bound sacs within the chloroplast that contain the pigments necessary for the **light-dependent reactions** of photosynthesis.
    - Thylakoids are organized into **grana** (stacks of thylakoids), which are connected by **stroma thylakoids** (also called lamellae).
    - The thylakoid membrane contains **chlorophyll** and other pigments, such as **carotenoids**, that absorb light energy.
    - **ATP synthase** enzymes are embedded in the thylakoid membrane, helping generate ATP during photosynthesis.
5. **Grana and Stroma Thylakoids:**
    - **Grana** are stacks of thylakoids that appear as flat, disk-like structures. They enhance the efficiency of light absorption.
    - **Stroma thylakoids** (or lamellae) are the unstacked regions that connect the grana. These thylakoids play an important role in facilitating the transfer of electrons during the light reactions of photosynthesis.
6. **Chlorophyll:**
    - Chlorophyll is the **green pigment** embedded in the thylakoid membrane that is responsible for capturing light energy, primarily in the blue and red wavelengths of light.
    - Chlorophyll absorbs light energy, which excites electrons and initiates the process of photosynthesis.
    - There are two main types of chlorophyll: **Chlorophyll a** (the primary pigment) and **Chlorophyll b** (which assists in light absorption and broadens the spectrum of light that plants can use).



Chloroplast

Functions of Chloroplasts

1. **Photosynthesis:**

- The primary function of chloroplasts is to conduct **photosynthesis**, which consists of two main stages:
  - **Light-dependent reactions** (occur in the thylakoid membranes): These reactions convert light energy into chemical energy in the form of **ATP** and **NADPH**, which are then used in the second stage.
  - **Calvin cycle** (light-independent reactions, occur in the stroma): This cycle uses the ATP and NADPH produced in the light-dependent reactions to fix carbon dioxide into organic molecules, ultimately producing glucose and other sugars.

2. **Production of Glucose:**
   - Through the Calvin cycle, chloroplasts fix **carbon dioxide** (CO_2) from the atmosphere into glucose ($C_6H_{12}O_6$), which serves as an energy source for the plant.
   - The glucose produced can be used by the plant immediately for energy or stored as starch for later use.
3. **Oxygen Production:**
   - During the light-dependent reactions of photosynthesis, **water** (H_2O) molecules are split to release **oxygen (O_2)** as a byproduct. This oxygen is then released into the atmosphere, making plants vital contributors to life on Earth.
4. **Synthesis of Metabolites:**
   - Chloroplasts are involved in synthesizing a variety of organic molecules, including amino acids, lipids, fatty acids, and certain vitamins.
   - **Starch** and other storage carbohydrates are synthesized in chloroplasts from glucose produced during photosynthesis.
5. **Regulation of Cellular Metabolism:**
   - Chloroplasts are involved in the regulation of certain aspects of **cellular metabolism**, especially related to energy storage and synthesis, by managing the flow of metabolites between the chloroplast and other organelles like the mitochondria and the cytoplasm.

5. What is the Nucleus? Write a Detailed Note on the Nuclear Pore Complex.

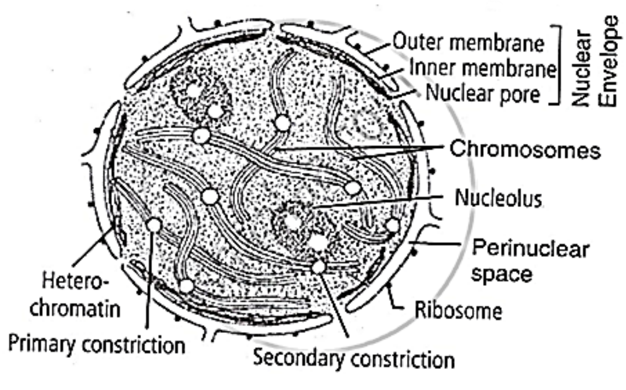
Ans.
Structure of the Nucleus

The nucleus has a complex structure consisting of several components, each with a specific function in maintaining and regulating cellular activities.

1. **Nuclear Envelope:**
   - The **nuclear envelope** is a double-layered membrane that surrounds the nucleus and separates the contents from the cytoplasm.
   - The outer membrane is continuous with the **rough endoplasmic reticulum (ER)**, and the inner membrane is lined by a network of proteins that help maintain the shape of the nucleus.
   - The nuclear envelope is perforated by **nuclear pores**, which regulate the transport of molecules between the nucleus and the cytoplasm.
2. **Nuclear Pores:**
   - **Nuclear pores** are large protein complexes embedded in the nuclear envelope that control the exchange of materials between the nucleus and the cytoplasm.
   - They allow the passage of molecules such as **RNA**, **ribosomal subunits**, and **proteins** into and out of the nucleus.

- The transport through nuclear pores is highly regulated and involves various **nucleoporins** (proteins forming the pore structure).

3. **Nucleoplasm (or Nuclear Matrix):**
   - **Nucleoplasm**, also called **nuclear sap**, is the semi-fluid substance inside the nucleus that surrounds the chromatin and the nucleolus.
   - It serves as a medium in which nuclear components are suspended and where various nuclear activities, such as **transcription** and **RNA processing**, occur.
   - It contains enzymes, nucleotides, and other molecules necessary for processes like **DNA replication** and **RNA synthesis**.
4. **Chromatin:**
   - **Chromatin** is a complex of **DNA** and **histone proteins** that makes up the genetic material in the nucleus.
   - It exists in two forms: **euchromatin** and **heterochromatin**:
     - **Euchromatin** is less condensed and is actively involved in transcription, as it is accessible for gene expression.
     - **Heterochromatin** is tightly packed and generally inactive, meaning its genes are not expressed under normal conditions.
   - During cell division, chromatin condenses to form **chromosomes**.
5. **Nucleolus:**
   - The **nucleolus** is a dense, spherical structure located within the nucleus, and it is the site of **ribosomal RNA (rRNA) synthesis** and the assembly of **ribosomal subunits**.
   - It is not surrounded by a membrane but consists of **DNA**, **RNA**, and proteins. The nucleolus is highly active during **protein synthesis**.
   - The nucleolus can be seen under a light microscope as a dark spot within the nucleus.
6. **Nuclear Lamina:**
   - The **nuclear lamina** is a dense network of protein filaments found on the inner side of the nuclear envelope.
   - It provides structural support to the nucleus, helps maintain the shape of the nuclear membrane, and plays a role in organizing chromatin and regulating nuclear events such as **DNA replication** and **cell division**.



Functions of the Nucleus :

1. **Genetic Material Storage:**
   - The nucleus stores the **genetic material** of the cell in the form of **DNA**. The DNA carries the information required for the synthesis of proteins and the regulation of cellular activities.
   - The **nuclear genome** is organized into chromosomes, each containing thousands of genes that code for various proteins.

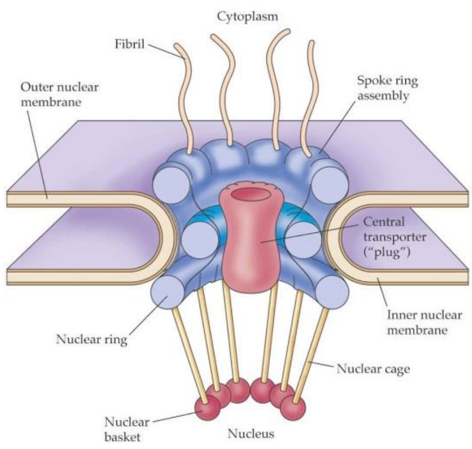
2. **DNA Replication:**
   - The nucleus is the site of **DNA replication** during the **S phase** of the cell cycle. This process ensures that the genetic material is accurately copied and passed on to daughter cells during cell division.
3. **Gene Expression and Protein Synthesis:**
   - The nucleus regulates **gene expression**, which is the process by which information from a gene is used to produce proteins.
   - Transcription of **DNA** into **messenger RNA (mRNA)** occurs in the nucleus, and the mRNA is then transported to the **cytoplasm** where it is translated into proteins by ribosomes.
   - The **nucleolus** plays a crucial role in the synthesis of **rRNA**, which is a component of **ribosomes**, the cellular machinery for protein synthesis.
4. **Regulation of Cell Cycle and Cell Division:**
   - The nucleus controls the **cell cycle**, including the stages of cell division: **mitosis** (for somatic cells) and **meiosis** (for gametes).
   - The replication of DNA during mitosis ensures that each daughter cell receives an identical copy of the genome.
   - The **nuclear envelope** disassembles and reassembles during cell division, ensuring that the chromosomes are segregated properly.
5. **Cellular Signaling:**
   - The nucleus plays a role in **cellular signaling** by integrating signals from the environment and controlling the transcription of genes in response to those signals.
   - Signaling molecules such as **hormones** and **growth factors** can affect the activity of genes in the nucleus, influencing cellular functions like growth, differentiation, and apoptosis (programmed cell death).

6. Write Short Notes on Structure and function of the Nuclear Pore Complex (NPC)

Ans. The **nuclear pore complex (NPC)** is a large and intricate protein structure that spans the nuclear envelope, which is the double membrane structure surrounding the nucleus in eukaryotic cells. It regulates the transport of molecules between the nucleus and the cytoplasm.

Structure of Nuclear Pore Complex:

1. **Nuclear Envelope**: The nuclear envelope consists of two lipid bilayers—**inner membrane** and **outer membrane**—that separate the nucleus from the cytoplasm.
2. **Nuclear Pores**: The nuclear envelope has multiple openings called **nuclear pores**, each about 100 nm in diameter. These pores are formed by the nuclear pore complex.
3. **Core Structure**: The NPC is made up of about 30 different proteins called **nucleoporins**. These nucleoporins form a large, cylindrical structure around the pore. It includes:
   - **Cytoplasmic fibrils**: Extend into the cytoplasm.
   - **Nucleoplasmic filaments**: Extend into the nucleoplasm.
   - **Central Channel**: A central passage that regulates molecular transport across the nuclear envelope.
4. **Basket-like Structure**: On the nucleoplasmic side, the NPC has a basket-like arrangement, which helps in the selective transport process.



Functions of Nuclear Pore Complex:

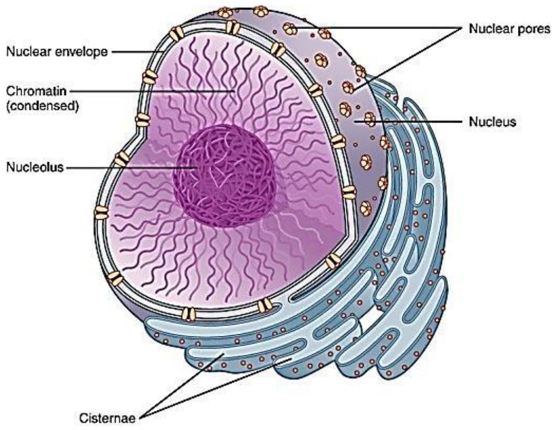
1. **Transport Regulation**: The primary function of the NPC is to regulate the exchange of materials between the **nucleus** and the **cytoplasm**. Small molecules like ions and water pass through the NPC passively, while larger molecules such as proteins, RNA, and ribosomal subunits require active transport.
2. **Selective Permeability**: The NPC acts as a selective barrier, controlling the movement of molecules in and out of the nucleus. It uses a **transport receptor system** to facilitate the entry and exit of specific molecules.
3. **Import and Export**:
    - **Nuclear Import**: Proteins that need to function within the nucleus (such as transcription factors or enzymes) are imported into the nucleus.
    - **Nuclear Export**: RNA molecules (like mRNA) and ribosomal subunits are exported from the nucleus to the cytoplasm for protein synthesis.
4. **Molecular Recognition**: The NPC contains specific **signal sequences** (like the **NLS – Nuclear Localization Signal** for proteins and **NES – Nuclear Export Signal** for RNA) that are recognized by transport receptors to direct molecules to their proper destinations.

7. Write a Detailed Note on the Nucleolus.

Ans. **Nucleolus :**

1. **Shape and Appearance:**
    - The nucleolus is generally round or oval in shape.
    - It is usually located near the center of the nucleus, although its position may vary depending on the cell type and the stage of the cell cycle.
    - It appears darker and more condensed when viewed under a microscope, due to its high concentration of RNA and protein.
2. **Substructures within the Nucleolus:** The nucleolus can be divided into three distinct regions, each with specific functions:
    - **Fibrillar Center (FC):**
        - This is the central region of the nucleolus, where the genes encoding ribosomal RNA (rRNA) are transcribed.
        - The fibrillar center contains the **DNA** responsible for the synthesis of rRNA and is associated with various proteins that regulate rRNA transcription.
    - **Dense Fibrillar Component (DFC):**
        - Surrounding the fibrillar center, the dense fibrillar component is rich in **rRNA** and **RNA polymerase I**.
        - Here, rRNA is processed and modified as it is synthesized from DNA.

- **Granular Component (GC):**
    - The granular component is found at the outermost edge of the nucleolus.
    - It contains partially assembled **ribosomal subunits** (composed of rRNA and proteins).
    - These subunits are then transported from the nucleolus to the cytoplasm where they combine to form functional ribosomes.



Function of the Nucleolus:

1. **Ribosome Biogenesis:**
    - The primary function of the nucleolus is the production and assembly of **ribosomal RNA (rRNA)** and **ribosomal subunits**.
    - **rRNA synthesis**: The **genes encoding rRNA** are transcribed in the fibrillar center of the nucleolus, and the transcribed rRNA undergoes processing and modification in the dense fibrillar component.
    - The rRNA is then combined with **ribosomal proteins**, which are imported into the nucleus from the cytoplasm. This assembly occurs in the granular component.
    - The assembled **ribosomal subunits** are exported to the cytoplasm through the **nuclear pore complexes**.
2. **Role in Protein Synthesis:**
    - Ribosomes are essential for **protein synthesis** as they are the sites where mRNA is translated into polypeptides. The nucleolus, by producing ribosomal subunits, plays a key role in enabling protein synthesis in the cytoplasm.
3. **Regulation of Cell Cycle and Apoptosis:**
    - The nucleolus is involved in regulating the **cell cycle** and **cellular stress responses**. Some nucleolar proteins play roles in the regulation of the cell cycle and apoptosis (programmed cell death).
    - During cellular stress or damage, nucleolar components may be redistributed or disassembled to modulate these processes.
4. **Storage of Certain Proteins:**
    - The nucleolus can serve as a storage site for **protein factors** that are necessary for processes such as **ribosome assembly** and **RNA processing**.

8. Write Short Notes on Microtubules, Microfilaments, and Intermediate Filaments.

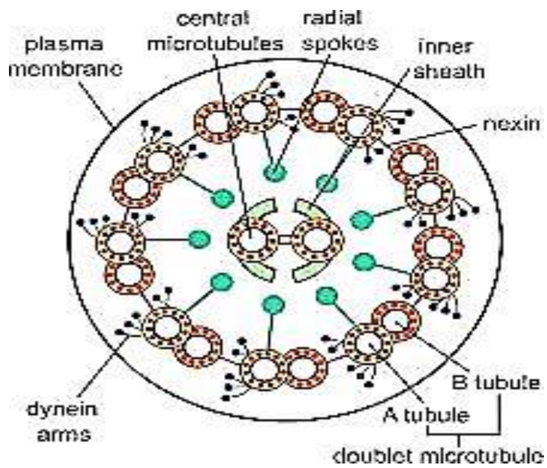
Ans. (i) **Microtubules:**

Microtubules are essential components of the **cytoskeleton**, the structural framework of the cell. They play a critical role in maintaining cell shape, enabling intracellular transport, facilitating cell division, and supporting cellular organization. Microtubules are dynamic structures that are involved in many cellular processes.

Structure of Microtubules

Microtubules are **hollow, cylindrical** structures composed of **tubulin proteins**. They are the largest type of cytoskeletal filaments, with a diameter of about **25 nm**.

1. **Tubulin Subunits:**
   - Microtubules are made up of **tubulin** dimers, which consist of two globular proteins: **alpha-tubulin** and **beta-tubulin**.
   - These dimers polymerize to form a linear protofilament. Several protofilaments (usually 13) align side by side to form the hollow microtubule structure.
2. **Polarity:**
   - Microtubules have **polarity**, meaning they have distinct "plus" and "minus" ends:
     - The **plus end** (also called the **fast-growing end**) is where **beta-tubulin** is exposed, and it grows more rapidly by adding tubulin dimers.
     - The **minus end** (also called the **slow-growing end**) is where **alpha-tubulin** is exposed, and it is typically anchored to the **microtubule-organizing center (MTOC)** or **centrosome** in animal cells.
   - This polarity is important for the directionality of intracellular transport and other functions.
3. **Dynamic Instability:**
   - Microtubules are highly dynamic and can rapidly grow and shrink in a process known as **dynamic instability**. They can polymerize (grow) and depolymerize (shrink) by the addition or loss of tubulin dimers at the ends.
   - **GTP-bound tubulin** promotes polymerization, while **GDP-bound tubulin** promotes depolymerization.



Functions of Microtubules

Microtubules are involved in a wide variety of essential cellular processes, including maintaining cell shape, facilitating transport, and enabling cell division.

1. **Cell Shape and Structure:**
   - Microtubules contribute to the **structural integrity** of the cell by providing mechanical support.

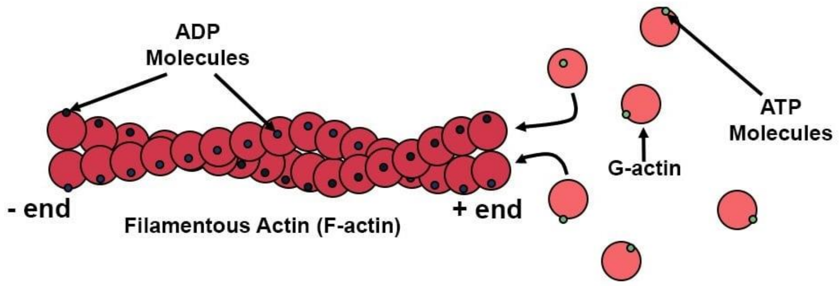
- They form part of the **cytoskeleton**, which helps maintain the cell's shape and provides rigidity.
- Microtubules assist in organizing the components of the cell, helping to establish the positions of organelles and other structures.

2. **Intracellular Transport:**
   - Microtubules serve as **tracks** for the transport of organelles, vesicles, and other cellular components within the cell.
   - Motor proteins such as **kinesins** and **dyneins** "walk" along the microtubules, using **ATP** to carry cargo to specific locations in the cell.
     - **Kinesins** typically move cargo towards the **plus end** (away from the nucleus).
     - **Dyneins** move cargo towards the **minus end** (towards the nucleus).
   - This transport is critical for processes such as **vesicle trafficking**, **spindle formation**, and **organelle positioning**.
3. **Cell Division (Mitosis and Meiosis):**
   - Microtubules play a central role in **mitosis** and **meiosis** by forming the **mitotic spindle**, which is essential for the accurate separation of chromosomes during cell division.
   - The **spindle fibers** are made up of microtubules that extend from the **centrosomes** to attach to the **kinetochores** of chromosomes. They ensure the chromosomes are equally distributed to the two daughter cells.
   - In **meiosis**, microtubules help in the separation of homologous chromosomes in **meiosis I** and sister chromatids in **meiosis II**.
4. **Ciliary and Flagellar Movement:**
   - Microtubules are the main structural components of **cilia** and **flagella**. These are hair-like projections that extend from the surface of some eukaryotic cells and are involved in movement or fluid propulsion.
   - The **axoneme** is the core structure of cilia and flagella, and it consists of a **9+2 arrangement** of microtubules (nine doublets of microtubules surrounding two central singlets).
   - **Dynein** motor proteins move along the microtubules, generating the sliding force required for the bending and movement of cilia and flagella.
5. **Cellular Signaling:**
   - Microtubules are involved in intracellular signaling and the distribution of signaling molecules. They help in organizing **signal transduction** pathways, thereby ensuring proper cellular responses to external stimuli.
   - They are also important in **endocytosis** and **exocytosis**, processes that rely on the trafficking of vesicles along the microtubules.

(ii) Microfilaments:

- They are also called actin filaments, as they consist of two intertwined strands of a globular protein known as actin.
- They are the polymers of the protein actin and the smallest filaments of the cytoskeleton.
- They have a vital role in cell movements, cell division, and muscle contraction.
- They are slender filaments of the cytoskeleton present in the cytoplasm of eukaryotic cells, with a diameter of about 5 to 8 nanometers.
- The flexible arrangement of filaments enables it to help in cell movement.
- The filaments play a vital role in contracting molecular motors driven by actomyosin.
- They provide shape and rigidity to the cell.

- They can disassemble and reassemble rapidly, enabling a cell to modify its shape and move.



Microfilaments

(iii) Intermediate Filaments:

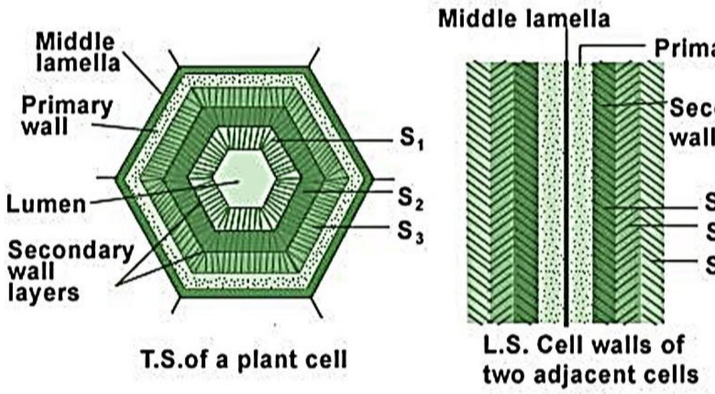
- These are cytoskeletal structural components present in the cells of vertebrates and many invertebrates.
- These are filaments that are intermediate in thickness between microfilaments and microtubules.
- They are made up of long subunits that are proteinaceous in nature, known as keratin.
- Keratin wound together forms threads, creating a rope-like structure.
- In accordance with microtubules, intermediate filaments are important for maintaining the structure and shape of the cell.
- These filaments provide tension support among the cells.
- These filaments help in the anchoring of the organelles inside the cell and also join cells to other cells by forming cell junctions.

9. Write Short Notes on Structure, Chemical Composition and function of the Plant Cell Wall.

Ans. Organization of the Plant Cell Wall :

The plant cell wall is organized into three main layers:

1. **Primary Cell Wall:**
   - The **primary cell wall** is the outermost layer and is synthesized while the cell is growing.
   - It is **flexible** and allows the cell to expand as it grows.
   - Composed mainly of **cellulose**, **hemicellulose**, and **pectin**, it provides structural support and protection to the cell.
2. **Middle Lamella:**
   - The **middle lamella** is a **pectin-rich** layer that lies between the primary cell walls of adjacent plant cells.
   - It acts as a **cement** that holds neighboring cells together and provides adhesion.
3. **Secondary Cell Wall (in some cells):**
   - The **secondary cell wall** is deposited inside the primary cell wall after the cell has stopped growing.
   - It is **thicker** and more rigid than the primary wall, mainly due to the deposition of **lignin**.
   - The secondary wall adds additional strength and rigidity, particularly in tissues like **xylem** and **sclerenchyma**.



Composition of Plant Cell Wall:

The plant cell wall is primarily composed of several polysaccharides, proteins, and other organic molecules, which vary in composition depending on the plant tissue. The major components of the plant cell wall are:

1. **Cellulose:**
   - **Cellulose** is the primary structural component of the plant cell wall.
   - It is a long-chain polymer made of **β-glucose** molecules, linked together by **β-1, 4-glycosidic bonds**.
   - Cellulose forms **microfibrils**, which are bundled together to form the rigid framework of the cell wall.
2. **Hemicellulose:**
   - **Hemicelluloses** are a group of polysaccharides that are composed of various sugar monomers such as **xylose**, **glucose**, **mannose**, and **arabinose**.
   - Hemicelluloses are branched and help bind the cellulose microfibrils together, providing additional structural support to the wall.
3. **Pectin:**
   - **Pectin** is a polysaccharide rich in **galacturonic acid**.
   - It acts as a **gel-like matrix** between cellulose fibers, helping to hold the plant cells together and providing flexibility.
   - Pectin is especially abundant in the **middle lamella**, the layer that glues adjacent plant cells together.
4. **Lignin:**
   - **Lignin** is a complex polymer composed of phenolic compounds.
   - It is primarily found in the **secondary cell wall**, where it helps to strengthen and waterproof the wall.
   - Lignin is abundant in **woody plants** and provides structural integrity to tissues like **xylem**.
5. **Proteins:**
   - **Proteins** in the cell wall, such as **extensins** and **expansins**, help in the modification of the wall's structure during growth and development.
   - **Extensins** help in cross-linking cellulose fibers, while **expansins** assist in loosening the wall during cell growth.

Functions of the Plant Cell Wall :

The plant cell wall has several critical functions that contribute to the overall growth, structure, and defense of the plant:

1. **Structural Support:**
    - The plant cell wall provides **rigidity** and **strength**, allowing the cell to maintain its shape and resist mechanical stress.
    - It helps the plant cell withstand **turgor pressure** from the central vacuole, which maintains the cell's internal pressure and prevents collapse.
2. **Protection:**
    - The cell wall acts as a **barrier** to protect the cell from mechanical injury, pathogens, and excessive water loss.
    - It prevents the entry of harmful microorganisms, while allowing the passage of nutrients and signaling molecules.
3. **Regulation of Growth:**
    - The plant cell wall regulates **cell expansion**. During growth, the wall must loosen to allow the cell to enlarge. **Expansins** are proteins that facilitate the loosening of the wall, enabling growth.
    - The wall can also **reinforce** itself by increasing the deposition of cellulose and lignin in response to environmental conditions.
4. **Cell Adhesion and Communication:**
    - The **middle lamella** helps in **cell-to-cell adhesion**, holding plant cells together to form tissues.
    - The **plasmodesmata**, channels that pass through the cell wall, allow direct communication and transport of materials between adjacent plant cells.
5. **Transport of Water and Solutes:**
    - The cell wall regulates the **movement of water** and solutes into and out of the cell, in collaboration with the **plasma membrane**.
    - The hydrophilic nature of pectin allows the cell wall to maintain **turgidity**, contributing to the plant's ability to retain water.

10. Write Short Notes on Structure, Chemical Composition and function of the Plasma Membrane.

Ans. Fluid Mosaic Model of Plasma Membrane:

The **Fluid Mosaic Model** is the most widely accepted model for the structure and behavior of the plasma membrane of cells. Proposed by **S.J. Singer** and **G.L. Nicolson** in 1972, the model describes the plasma membrane as a **dynamic**, **flexible**, and **asymmetrical** structure made up of a **mosaic** of various components (lipids, proteins, and carbohydrates) that move fluidly within the lipid bilayer.

According to this model, the membrane is a fluid structure with various proteins embedded in or attached to a double layer of phospholipids.

1. Phospholipid Bilayer

- The **phospholipid bilayer** is the fundamental structure of the plasma membrane.
- **Phospholipids** are molecules with a **hydrophilic (water-attracting) head** and two **hydrophobic (water-repellent) tails**.
- In the bilayer, the hydrophilic heads face outward toward the aqueous environment (extracellular fluid and cytoplasm), while the hydrophobic tails face inward, away from water.

- This arrangement forms a **semi-permeable membrane** that is flexible and allows for the movement of small non-polar molecules, such as gases and lipids, across the membrane.

2. Membrane Proteins

Membrane proteins are interspersed throughout the lipid bilayer and serve various functions:

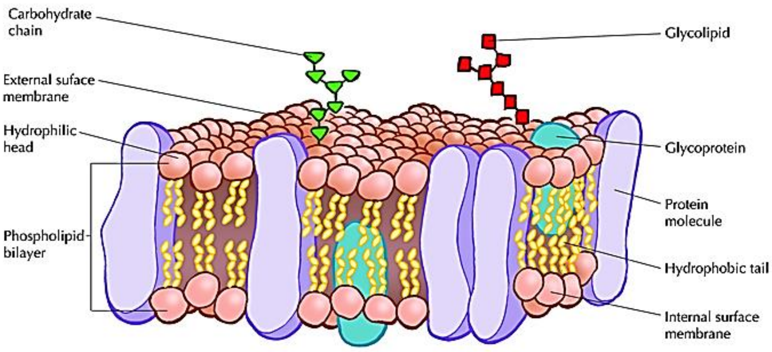
- **Integral Proteins**: These proteins are embedded within the phospholipid bilayer and often span the entire membrane. They are involved in transport, acting as channels or carriers for molecules.
- **Peripheral Proteins**: These proteins are attached to the inner or outer surface of the membrane but do not penetrate the bilayer. They play roles in signaling, cell recognition, and maintaining the shape of the cell.
- **Glycoproteins**: Integral or peripheral proteins that have carbohydrate chains attached to them. They are involved in cell-cell recognition and signaling.

3. Carbohydrates

- **Carbohydrates** are often attached to proteins (glycoproteins) or lipids (glycolipids) on the extracellular surface of the membrane.
- These carbohydrate chains form the **glycocalyx**, which is involved in cell recognition, signaling, and protection from mechanical damage and pathogens.

4. Cholesterol

- **Cholesterol** molecules are interspersed within the phospholipid bilayer, helping to stabilize the membrane by preventing it from becoming too fluid or too rigid.
- Cholesterol maintains the **membrane's flexibility**, especially in varying temperature conditions.



Functions of the Plasma Membrane

The plasma membrane is vital to the function of the cell. It performs several key roles:

1. **Selective Permeability**:
   - The plasma membrane is **semi-permeable**, meaning it selectively allows certain molecules to pass through while blocking others.
   - Small, non-polar molecules (like oxygen and carbon dioxide) and lipids can diffuse easily through the bilayer. Larger, polar molecules or ions require transport proteins to facilitate their movement across the membrane.
2. **Cell Communication**:

   - The plasma membrane is involved in **cell signaling** through receptors that recognize and respond to signaling molecules like hormones and neurotransmitters.
   - **Receptor proteins** on the membrane surface receive signals from the external environment, triggering intracellular signaling pathways.
3. **Cell Protection**:
   - The plasma membrane acts as a **barrier** that protects the internal components of the cell from harmful substances, pathogens, and mechanical stress.
   - It also helps maintain the **homeostasis** of the cell by regulating the flow of ions and molecules into and out of the cell.
4. **Transport of Substances**:
   - The plasma membrane is responsible for the **transport of materials** across the cell, such as nutrients, ions, and waste products.
   - Transport mechanisms include:
     - **Passive transport** (e.g., diffusion, osmosis) that does not require energy.
     - **Active transport** (e.g., pump systems) that requires energy (ATP) to move substances against their concentration gradient.
     - **Endocytosis** (cell engulfing substances) and **exocytosis** (expelling substances) for large molecules or particles.
5. **Cell Recognition**:
   - The **glycocalyx** (carbohydrate portion) on the cell membrane helps cells recognize each other.
   - This is important in processes like **immune response** and **tissue formation** during development.
6. **Structural Support**:
   - The plasma membrane helps maintain the **shape** and **structure** of the cell.
   - It is anchored to the cell's internal cytoskeleton, which provides additional mechanical support and helps in maintaining cell shape

11. Write Short Notes on Structure, Chemical Composition and function of the Endoplasmic reticulum.

Ans. The **Endoplasmic Reticulum (ER)** is a complex network of membrane-bound tubules and sacs that extend throughout the cytoplasm. It is one of the largest organelles in eukaryotic cells and plays a central role in cellular processes like protein and lipid synthesis.

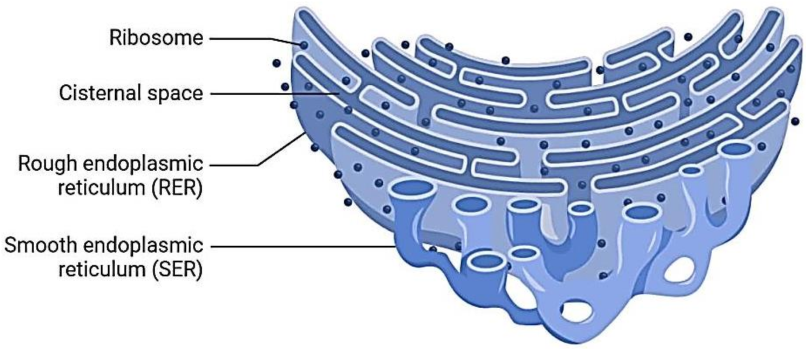
- **Types of ER**:
  - **Rough Endoplasmic Reticulum (RER)**: Studded with ribosomes on its cytoplasmic surface, making it appear rough. It is primarily involved in **protein synthesis** and **folding**.
  - **Smooth Endoplasmic Reticulum (SER)**: Lacks ribosomes and appears smooth. It is involved in **lipid synthesis**, **carbohydrate metabolism**, and **detoxification**.

The **Endoplasmic Reticulum (ER)** is a membranous organelle found in eukaryotic cells. It plays a central role in the synthesis of proteins, lipids, and other cellular processes. The ER consists of an interconnected network of **membrane-bound tubules, vesicles, and cisternae**, which form an extensive system throughout the cytoplasm. The structure of the ER can be described in more detail as follows:

Membranous Network: The ER consists of a **single continuous membrane system** that is connected to the **nuclear envelope**, creating a large surface area for cellular activities.

Cisternae: The ER has flattened sacs known as **cisternae**, which are connected to each other and form a network. These sacs contain the lumen, the space inside the ER that is separate from the cytoplasm.

Tubules: The ER also contains **tubular structures**, which are long, tube-like networks connecting the cisternae.



Structure of Endoplasmic reticulum

The **Endoplasmic Reticulum** is primarily composed of:

- **Lipids**: The ER membrane is made up of a **lipid bilayer** composed of phospholipids and cholesterol, which form the structural framework of the membrane.
- **Proteins**: The membrane contains various **integral proteins** and **peripheral proteins** that are involved in transport, enzymatic activity, and cell signaling. The **ribosomes** on the RER are responsible for protein synthesis.
- **Carbohydrates**: Small amounts of carbohydrates may be attached to membrane proteins (glycoproteins) or lipids (glycolipids) in the ER, particularly in the RER, where glycosylation of proteins occurs.

Functions of Endoplasmic Reticulum:

The Endoplasmic Reticulum has several crucial functions in the cell, which can be categorized according to its types:

Functions of Rough ER (RER):

1. **Protein Synthesis**: The ribosomes on the surface of the RER synthesize proteins, especially those meant for secretion, membrane insertion, or lysosomal enzymes.
2. **Protein Folding and Modification**: It helps in the proper folding of proteins and some initial modifications such as **glycosylation**.
3. **Quality Control**: Misfolded or incomplete proteins are detected and either refolded or degraded.

Functions of Smooth ER (SER):

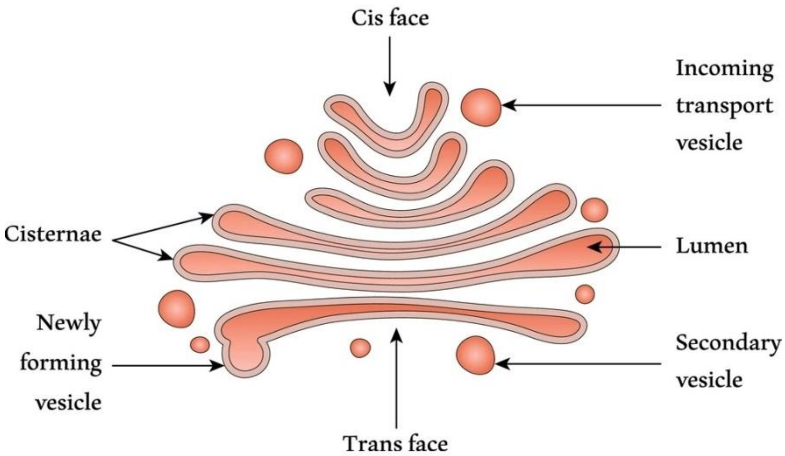
1. **Lipid Synthesis**: The SER is involved in the synthesis of **phospholipids** and **steroid hormones**, essential for cell membrane formation and other functions.
2. **Detoxification**: It helps in the detoxification of **metabolic waste products**, drugs, and harmful chemicals in the liver cells.
3. **Carbohydrate Metabolism**: The SER plays a role in the conversion of **glycogen** to **glucose** in liver and muscle cells.
4. **Storage of Calcium Ions**: The SER stores calcium ions (important for muscle function and signal transduction) in muscle cells and other cells.
5. **Transport of Lipids**: The SER transports lipids and other molecules to various parts of the cell or organelles.

12. Write Short Notes on Structure, Chemical Composition and function of the Golgi Apparatus.

Ans. Structure of Golgi Apparatus:

The **Golgi apparatus** (also known as the **Golgi complex** or **Golgi body**) is an essential organelle in eukaryotic cells involved in the modification, sorting, and packaging of proteins and lipids for transport. It is composed of a series of membrane-bound structures:

- **Cisternae**: The Golgi apparatus consists of flattened, stacked, **membrane-bound sacs** called **cisternae**. These cisternae are stacked in a parallel arrangement and form distinct regions within the Golgi body.
- **Regions of Golgi Apparatus**:
    1. **Cis face (Entry face)**: The cis face is located near the **endoplasmic reticulum (ER)**. It is the receiving side of the Golgi, where transport vesicles from the ER fuse to deliver proteins and lipids.
    2. **Trans face (Exit face)**: The trans face is on the opposite side, where vesicles are formed and transport processed materials to other parts of the cell or to the cell surface.
    3. **Medial region**: The area between the cis and trans faces, where further modifications to proteins and lipids occur.
- **Vesicles**: Small vesicles that bud off from the Golgi apparatus, containing the modified proteins or lipids that are either transported to their final destinations within or outside the cell.



Chemical Composition of Golgi Apparatus:

The Golgi apparatus is primarily composed of the following components:

- **Lipids**: The Golgi membrane is made up of a **phospholipid bilayer** with associated **cholesterol** that maintains membrane fluidity.
- **Proteins**: The Golgi apparatus contains **membrane-bound proteins** (which are involved in vesicle trafficking, processing, and recognition) and **enzymes** that modify proteins and lipids. These enzymes include:
    - **Glycosyltransferases**: Add sugar molecules to proteins (glycosylation).
    - **Proteases**: Cleave peptide bonds to activate or modify proteins.
    - **Phosphatases**: Remove phosphate groups from proteins.

- **Carbohydrates**: The Golgi is involved in **glycosylation**, where carbohydrate groups are added to proteins and lipids, forming **glycoproteins** and **glycolipids**.

Functions of Golgi Apparatus:

The Golgi apparatus has several critical functions in the cell, primarily related to processing and sorting proteins and lipids:

- **Protein Modification**:
  - The Golgi apparatus modifies proteins received from the **endoplasmic reticulum (ER)**. These modifications can include the addition of **carbohydrates** (glycosylation), **phosphate groups** (phosphorylation), and **sulfate groups**.
- **Protein Sorting and Packaging**:
  - After modification, the Golgi sorts proteins and lipids and packages them into vesicles that are directed to their correct destinations, such as the **plasma membrane**, **lysosomes**, or for secretion outside the cell.
- **Glycosylation**:
  - A significant function of the Golgi is the **glycosylation** of proteins and lipids, which involves the attachment of sugar molecules. This process is important for the function and stability of many proteins, as well as for their recognition by other cells.
- **Synthesis of Glycolipids**:
  - The Golgi is involved in the synthesis of **glycolipids**, which are essential components of cell membranes.
- **Vesicle Formation**:
  - The Golgi apparatus forms vesicles that transport processed proteins and lipids to the cell surface for **exocytosis** or deliver them to **lysosomes** for digestion.
- **Post-Translational Modifications**:
  - The Golgi modifies proteins after they have been synthesized in the rough ER, including cleaving pro-proteins into their active forms.
- **Lysosome Formation**:
  - The Golgi apparatus is responsible for the formation of **lysosomes** by packaging digestive enzymes into vesicles, which then mature into lysosomes.

13. Write detailed notes on Protein Shorting and Protein Targeting.

Ans. Protein Sorting:

Protein sorting refers to the process by which newly synthesized proteins are directed to their correct location within the cell or outside the cell. After being synthesized in the **endoplasmic reticulum (ER)**, proteins need to be sorted into specific compartments such as the **nucleus**, **mitochondria**, **plasma membrane**, **lysosomes**, or secreted outside the cell. This process ensures that proteins perform their specific functions in the correct cellular context.

- **Endoplasmic Reticulum (ER)**: Proteins are first synthesized in the rough ER, where they are modified and then transported to the Golgi apparatus for further processing.
- **Golgi Apparatus**: The Golgi sorts and packages proteins into vesicles, which then carry the proteins to their destinations.
- **Vesicle Transport**: Proteins are delivered to their final destination via vesicles. For example:
  - **Exocytosis**: Proteins destined for secretion are transported to the plasma membrane.
  - **Endocytosis**: Membrane proteins are incorporated into the plasma membrane.

- **Lysosomes**: Proteins destined for lysosomal digestion are packaged into lysosomal vesicles.

Protein Targeting:

Protein targeting is the mechanism that directs proteins to their specific subcellular locations. Unlike protein sorting, which involves distribution after modification, targeting ensures that proteins are directed to the correct location immediately after synthesis.

- **Signal Sequences**: Proteins contain specific **signal peptides** or **signal sequences** that act as "tags" for targeting. These sequences direct proteins to certain organelles or membranes. For example:
    - **Nuclear Localization Signal (NLS)**: Directs proteins to the **nucleus**.
    - **Mitochondrial Targeting Signal**: Directs proteins to the **mitochondria**.
    - **Signal Peptide for ER**: Directs proteins to the **endoplasmic reticulum** for co-translational insertion.
- **Signal Recognition Particle (SRP)**: The SRP helps guide ribosome-bound proteins to the ER membrane, where they are inserted into the lumen of the ER or embedded into the ER membrane.
- **Post-Translational Targeting**: Some proteins are synthesized in the cytoplasm and later targeted to organelles like the mitochondria or the nucleus using specific signals that are recognized after translation.
- **Glycosylation and Lipidation**: During protein targeting, modifications such as **glycosylation** or **lipidation** may occur to ensure proper localization and function of proteins within membranes or organelles.