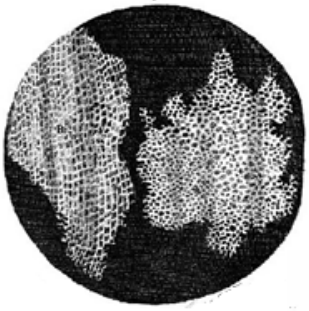
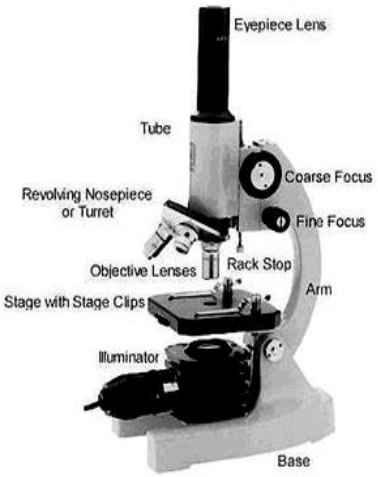


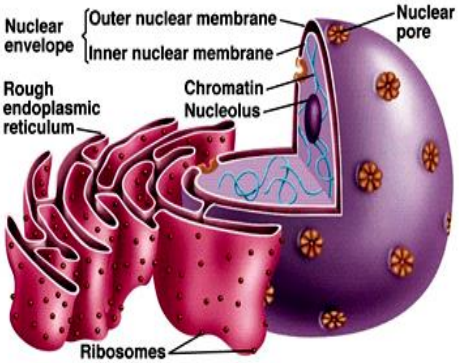
7 Cell Biology

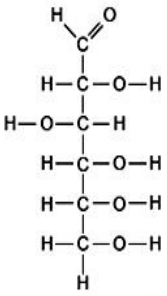


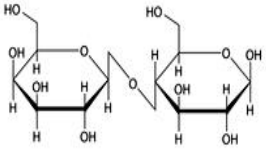


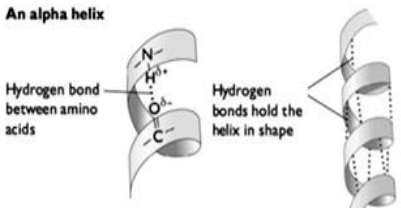
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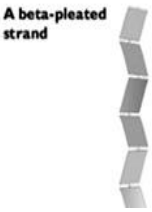


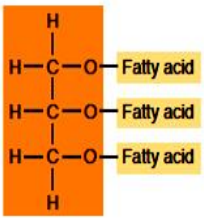












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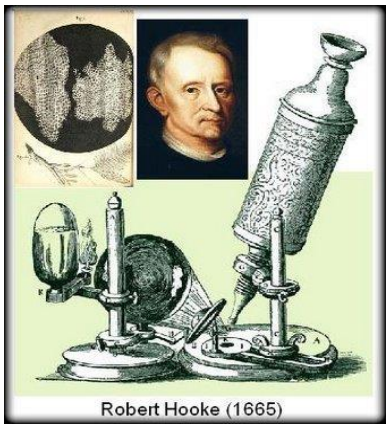
Introduction:

Cell biology or **cytology** is the study of cellular structure and function.

- **Cell biology** is a branch of biology that studies the structure, components and functions of the cell.
- **All living cells must:**
  (a) Obtain food and energy
  (b) Convert energy into a form the cell can use
  (c) Construct and maintain the molecules that make up cell structures
  (d) Carry chemical reactions known as **metabolism** (**metabolism** can either be **catabolism** or anabolism)
  (e) Eliminate wastes
  (f) Reproduce

7.1 *Cell Structure and Function:*

The **cell** is the structural and functional unit in organisms.
All living organisms are composed of one (unicellular) or more (multicellular) cells.
Cells vary greatly in size, shape, content and function.
Most of the cells have at least three components; **plasma membrane**, **cytoplasm** and **genetic material**.


Robert Hooke (1665)

➢ **Plasma membrane**
- The plasma membrane is also known as cell membrane
- It is a double layer of **phospholipid** embedded in a variety of **proteins**
- Functions of plasma membrane:
  1. It isolates the contents of the cell from its external environment
  2. It regulates movement of substances in and out of the cell
  3. It allows interaction with other cells

➢ **Cytoplasm**
- It is a semi-fluid (gel-like fluid) containing all the organelles the cell needs to do its function
- The liquid portion of the cytoplasm is called **cytosol**
- It is the site for many important chemical reactions to take place

➢ **Genetic material**
- The genetic material (DNA – deoxyribonucleic acid) is the heredity material in the cell that determines the composition of the organism, and also controls all cells' activities including protein synthesis and cell reproduction.
- In **eukaryotic cells**, DNA is in the nucleus and **prokaryotic cell**, DNA is in cytoplasm

Discovery of the Cell:

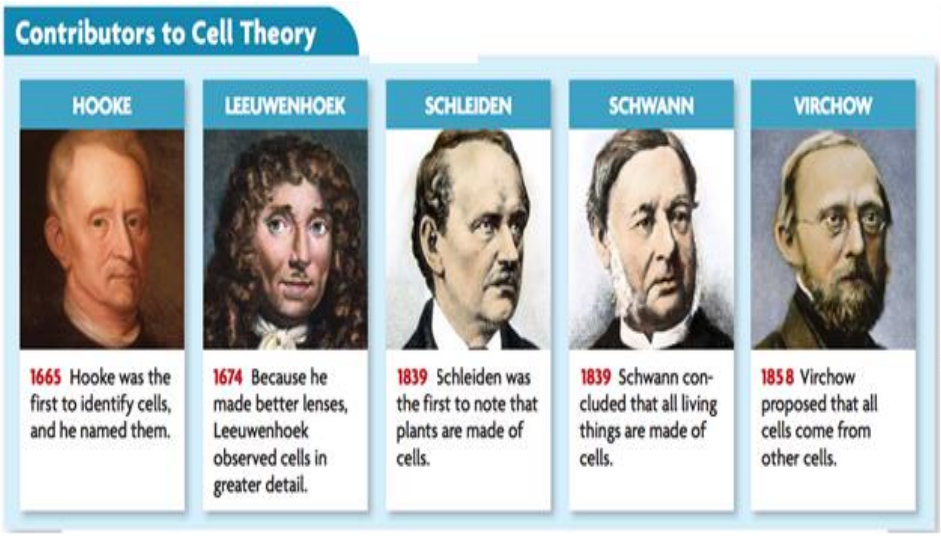
- The term cell was first named and coined by the English scientist **Robert Hooke** in **1665**.
- **Robert Hooke** examined a thin piece of cork of 'Oak tree' under his old microscope and observed tiny pores like boxes or small room-like structures; which he named **cell**.
- **Cells** are microscopic and we can only see them with the **help of microscope**

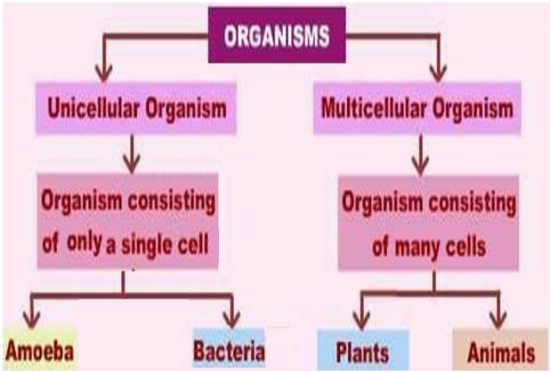
Contributions to the Cell:

- **Mathias Jakob Schleiden (1839),** a German Botanist, stated that ' **plant are made of cells**'
- **Theodor Schwan (1839),** a German Zoologist, stated that '**animals are made of cells**'
- **Rudolf Virchow (1858),** a German Biologist described that '**all cells come from pre-existing cells by cell division**'.

The Cell Theory:

- Cell theory is composed of 3 statements developed by several different scientists
  1. Cells are the smallest structural and functional unit of living things
  2. All cells arise from pre-existing cells by cell division
  3. All organisms are composed of one or more cells





Definitions of the Cell

- Cell is the smallest structural and functional unit of life
- Cell is the basic building of living things
- Cell is the fundamental unit of life

Types of Cells

- The two main types of cells on earth are:
  1. Prokaryotic cells and
  2. Eukaryotic cells

Prokaryotic Cells:

- **Prokaryotic cells** are cells without true nucleus
  (***Pro***= before, and ***karyon*** = nucleus)
- Prokaryotic cells are found in single-celled organisms that lack both a true nucleus and other membrane-bounded organelles.
- Organisms with prokaryotic cells are called **prokaryotes,** such as bacteria

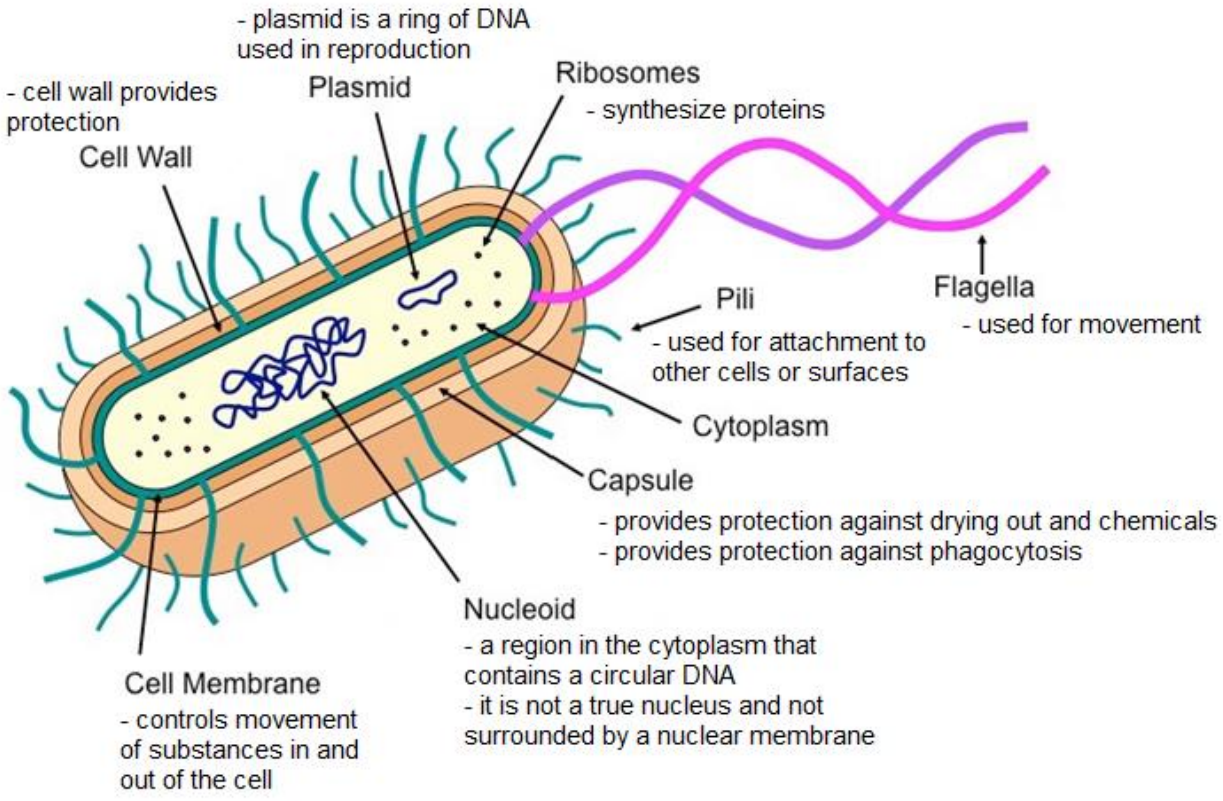


Figure: General structure of prokaryotic cell

Eukaryotic Cells:

- **Eukaryotic cells** are cells that contain a nucleus. (***Eu***= true, and ***karyon***= nucleus)
- Eukaryotic cells are usually larger than prokaryotic cells
- Eukaryotic cells are found in multicellular organisms.
- Eukaryotic cells contain both nucleus and other membrane-bounded organelles.
- Organisms with eukaryotic cells are called **eukaryotes,** such as animals and plants. The below diagrams illustrate two types of eukaryotic cells, animal and plant cells

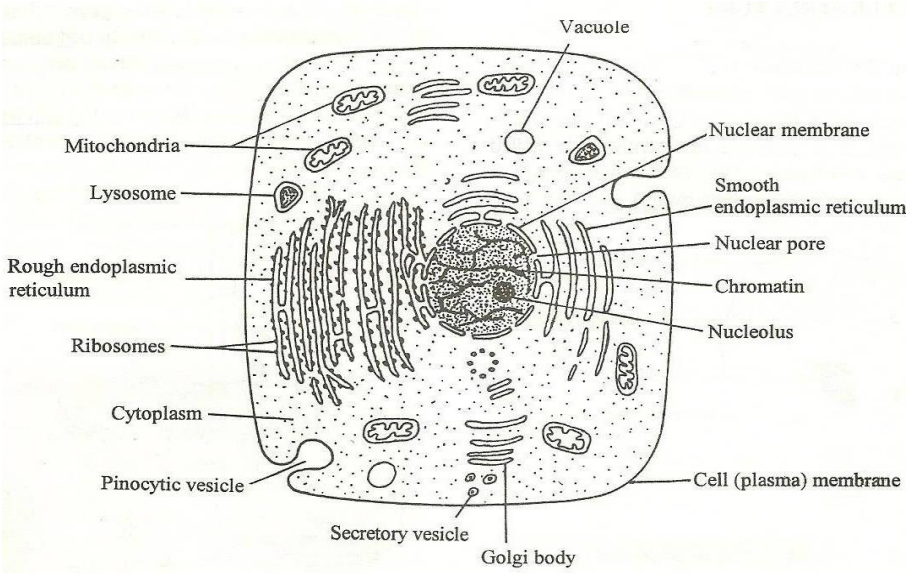


Figure: An animal cell

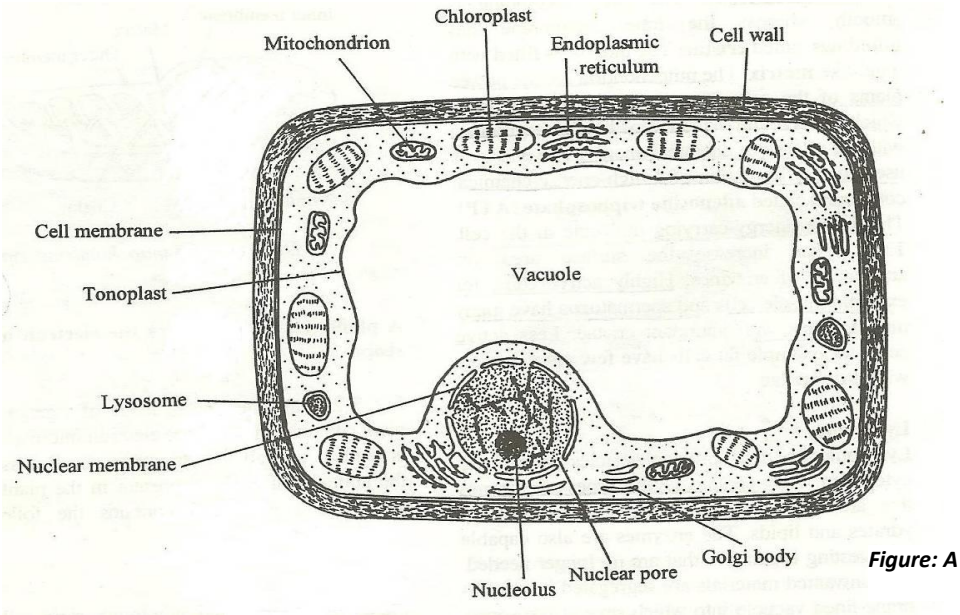
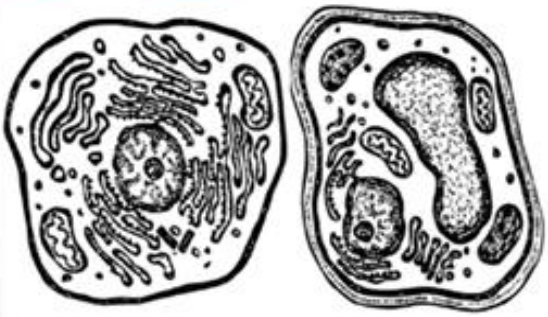


Figure: A plant cell

PROKARYOTIC CELL *Pro = "before", karyon = "nucleus*	EUKARYOTIC CELL *Eu = "true", karyon = "nucleus"*
 *Bacterium Cell*	 *Animal Cell* *Plant Cell*
• Smaller (cell size: **1-10µm**)	• Larger (cell size: **10 - 100µm**)
• Always unicellular	• Often multicellular
• Lacks true nucleus	• Has true nucleus
• **Ribosomes are small**	• **Ribosomes are large**
• Cell wall is present	• Some contain cell wall e.g plant cells, but not animal cells
• Lacks membrane-bounded organelles	• Contain membrane-bounded organelles
• Reproduction is asexual (binary fission)	• Reproduction may be asexual or sexual (mitosis/meiosis)
• DNA is circular without proteins	• DNA is linear associated with proteins
• DNA is found in the cytoplasm (nucleoid)	• DNA is found in the nucleus
• No cytoskeleton	• Always has a cytoskeleton

The Nucleus: Control Center of the Cell

- Nucleus is a double-membrane bounded organelle found in eukaryotic cells, except mature red blood cells in mammals.
- In eukaryotic cells, most of the genetic material (DNA – deoxyribonucleic acid) is housed within the nucleus.
- The nucleus is known as the control center of the cell as it directs the activities of a cell.

- The nucleus contains a semi-fluid called **nucleoplasm** in which both genetic material and nucleolus are suspended in it.
- The nucleus consists of three main structures, which are:
  1. Nuclear envelope
  2. Nuclear pores
  3. Chromatin
  4. Nucleolus

The Nuclear envelope

The nuclear envelope is a double membrane that encloses the nucleus of eukaryotic cells.
The outer membrane of the nuclear envelope is attached with the membranes of endoplasmic reticulum.
The nuclear membrane separates the nuclear material from rest of the cell's contents.
The nuclear envelope is full of small holes called **nuclear pores.**
The nuclear pores allow materials to pass between the nucleus and cytoplasm.

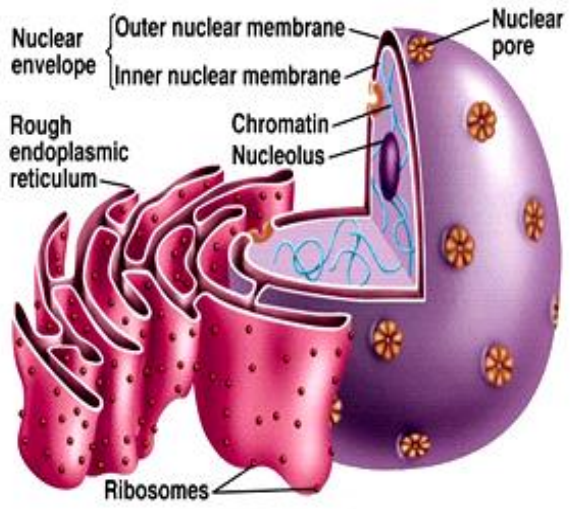


Figure: Structures of the nucleus

Chromatin: The Hereditary Material

- When the cell is not dividing, the nucleus contains a loosened network of fibers called **chromatin.**
- Chromatin is a loosely coiled fibers of DNA in the nucleus
- During the cell division, the **chromatin** condenses to form **chromosomes.**

The Nucleolus: Site of Ribosome Assembly

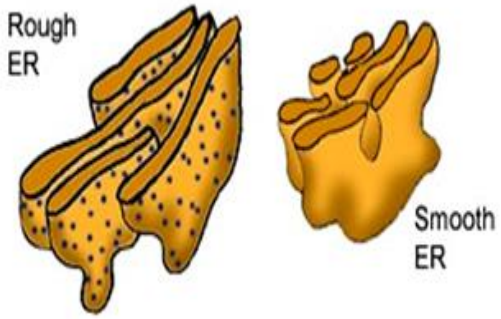
- Nucleoli ('little nuclei') are darkly staining structures in the nucleus of eukaryotic cells.
- Nucleolus consists RNA and proteins
- Nucleoli are the sites of ribosome synthesis
- During cell division, the nucleolus disappears

Functions of the Nucleus:

1. It controls the activity of the cell and inheritance
2. It regulates the information needed to synthesize proteins
3. It controls cell reproduction (regulates cell division)

Endoplasmic Reticulum (ER)

- Endoplasmic reticulum is a network of parallel interconnected flattened tubes enclosed by a membrane
- It is present in eukaryotic cells but absent in prokaryotic cells and RBCs
- **Types of endoplasmic reticulum are:**
  1. Rough endoplasmic reticulum (Rough ER) and
  2. Smooth endoplasmic reticulum (Smooth ER)
- The surface of rough endoplasmic reticulum is attached with ribosomes, which give it a rough appearance while smooth endoplasmic reticulum has no ribosomes on its outer surface



Major Functions of Endoplasmic Reticulum:

1. Keeps the cell's shape
2. Synthesizes lipids and steroid hormones
3. Transports materials to other organelles in the cell
4. Breaks down foreign chemical substances
5. Play an important role in the formation of the skeletal framework
6. They provide the increased surface area for cellular reactions

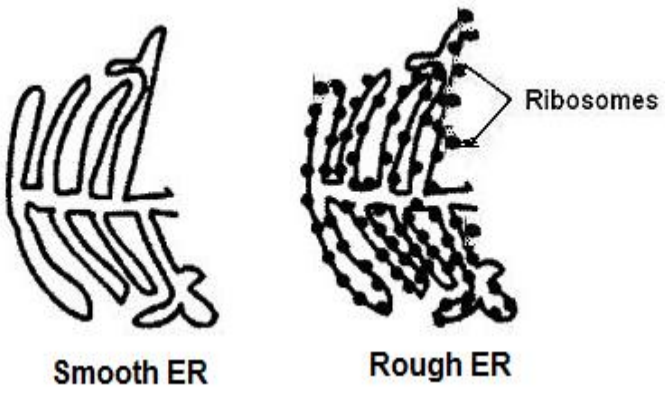


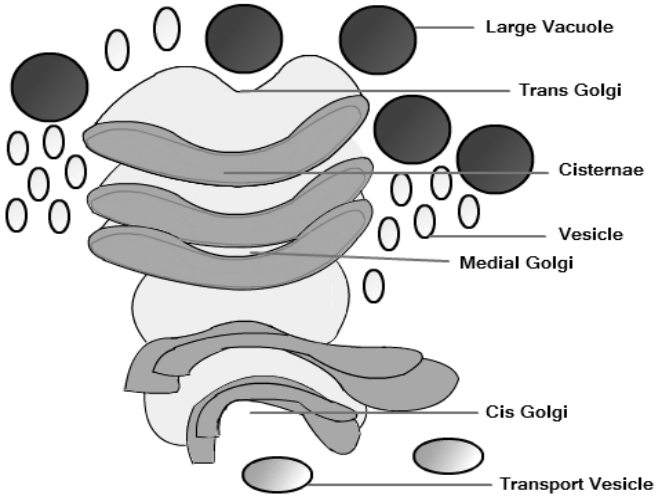
Figure: Endoplasmic reticulum

The structural and functional difference between Rough and Smooth ER

Rough Endoplasmic Reticulum	Smooth Endoplasmic Reticulum
Always attached on the nuclear membrane Mainly found in protein forming cells	May attach or found in the cytoplasm Mainly found in lipid forming cells
Appears rough Ribosomes attach on it which makes rough in appearance	Appears smooth Have no Ribosomes on it
Transport the synthesized proteins	Synthesize lipids and steroid hormones

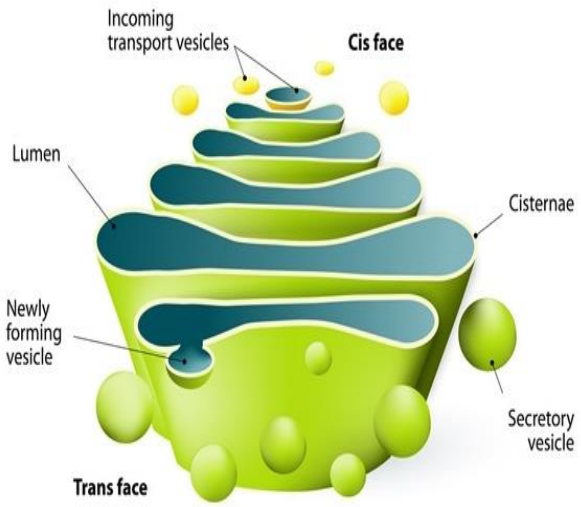
Golgi complex: Processing and Packaging

- Golgi apparatus is also known as **Golgi body**; **Golgi apparatus** or **Golgi.**
- Golgi apparatus was discovered in the year 1898 by an Italian biologist **Camillo Golgi**.
- Golgi bodies are flattened membranous sacs found in the cytoplasm of all eukaryotic cells except RBCs and also absent in prokaryotic cells.
- The stacks of flattened sacs of Golgi body are known as **cisternae**.
- The membranes of one end of the stack is known as the **'cis-face',** it is the 'receiving department' of the Golgi body which is close to the endoplasmic reticulum; while the other end of the stack is called '**tran-face'** and is the 'shipping department' of the Golgi body.
- Golgi body **modifies** and **sorts** any received substances and also **packages** materials into **vesicles (**secretary vesicles) which are either transported to other parts of the cell or outside of the cell for export by **exocytosis.**



Functions of the Golgi body:

1. It separates or sorts received substances
   - For example, separating digestive enzymes from hormones
2. It modifies molecules
   - For example adding sugar to proteins to make glycoproteins
3. It packages materials into vesicles for transport
4. It also stores the packed substances
5. It is the major site of carbohydrate synthesizes
6. It creates and produces lysosomes
7. Produces enzymes
8. Synthesis cell wall components for plants, e.g. cellulose



Lysosomes:

- Lysosomes are small spherical bags surrounded by a single membrane which contain **digestive enzymes.**
- Lysosomes are also known as **digestive bags, suicide sacs** or **cellular house keepers.**
- **Lysosomes** Contain splitting enzymes that digest worn out tissue and foreign material in the cell.

Functions of the Lysosomes:

1. They destroy poorly working or malfunctioning organelles
2. They break down unwanted substances such as old and damaged cells
3. They destroy any foreign particles
4. They break down unwanted substances in the cell.
5. They digest food particles such as proteins, fats and carbohydrates

Mitochondria:

- Mitochondria (sing.; mitochondrion) are rod-shaped and double membrane bound organelles with folded inner structures found in the cytoplasm of most eukaryotic cells.
- Mitochondrion is the site for aerobic respiration to generate energy from glucose for cellular activity.
- Mitochondria are sites of many biochemical reactions of aerobic respiration.
- It is the power house of the cell (site of cellular respiration)

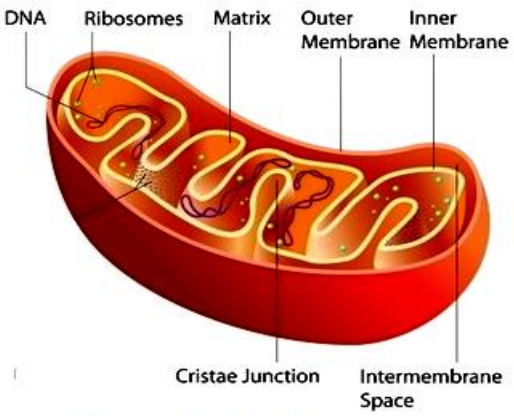


Figure: Mitochondrion

- These organelles generate most of the energy of the cell and store it in the form of adenosine triphosphate (ATP) which is used a source of chemical energy.

Structure of Mitochondria:

- Mitochondria contain double membrane, an outer and inner membrane
- The membranes are made up of **phospholipids** and **proteins**
- The space between the outer and inner membrane of mitochondria is known as **inter-membrane space**
- The outer membrane is freely permeable to nutrients, ions, energy molecules like ATP and ADP
-

- The outer membrane controls the entry and exit of substances into and out of the mitochondria.
- The inner membrane of mitochondria is folded many times which is known as **cristae.**
- **Cristae** (the folded inner membrane) increase surface area of mitochondria
- The inner membrane of mitochondria is filled with fluid called **matrix** which contains mixture of proteins, enzymes (ATP synthase), ribosomes and DNA.

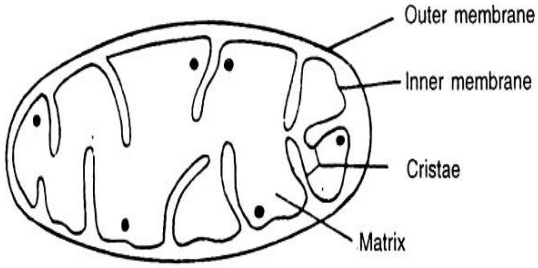


Fig. structure of mitochondria.

Functions of Mitochondria:

1. Sites of many biochemical reactions of aerobic respiration (site energy production)
2. Produces ATP (Adenosine Triphosphate) in which energy for cell activities is stored.

Cytoskeleton:

- **Cytoskeleton** is a network of protein filaments that extends throughout the cytosol in the cytoplasm.
- Cytoskeleton (also known as **CSK**) is an intracellular network of protein filaments; involved in determining cell's shape, cell movement and intracellular transport of substances within the cell.
- Eukaryotic cells contain three main kinds of cytoskeletal filaments or cytoskeletal protein fibers (also known as protein element of cytoskeleton):

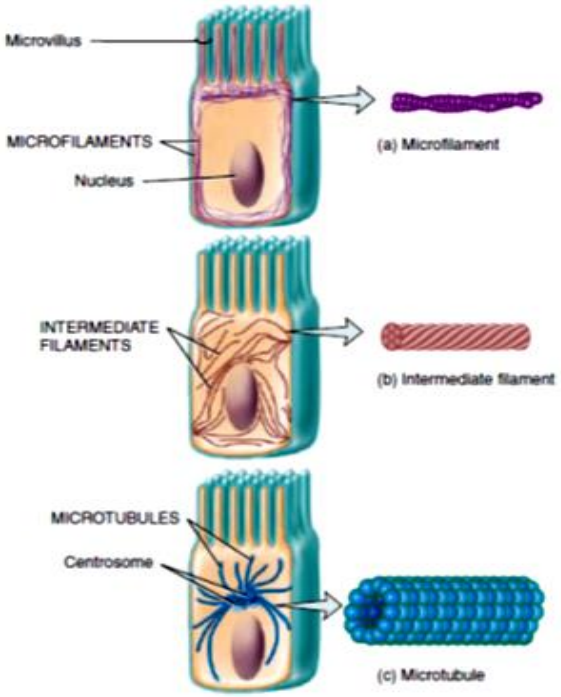
1. Microfilaments (actin microfilament):

- Microfilaments are the thinnest filaments of the cytoskeleton
- Microfilaments are thin thread-like strands in the cytoplasm.
- Microfilaments are contractile proteins that contain two main types of proteins **actin** and **myosin.**
- In muscle cells, for example, microfilaments combine to form ***myofibrils***, which help these cells contract.
- Microfilaments also form microscopic fingerlike projections called **microvilli** (singular: *microvillus*).
- **Microvilli** increase the surface area of the cell and so increase the rate of absorption.
- **Microvilli** are abundant on cells involved in absorption, such as the epithelial cells that line the small intestine.

2. **Microtubules (tubulin)**:
   - Microtubules are long, slender tubes with diameters two or three times those of microfilaments.
   - Microtubules are composed of molecules of a globular protein called **tubulin**, attached in a spiral to form a long tube.
   - They are important in cell division.
   - They form **cilia** and **flagella**, which are considered part of the cytoskeleton.
   - They also play key roles in cellular intracellular transport, e.g. organelles and vesicles.

3. Intermediate filament

- Intermediate filaments lie between microfilaments and microtubules in diameter.
- They are abundant in skin cells and neurons, but scarce in other cell types.
- Intermediate filaments are made up of different proteins in different cell types. Different intermediate filaments are:
  a. Made of**keratin**. Keratin is present in general in epithelial cells, e.g. skin
  b. **Neurofilaments** of neural cells.
  c. Made of **lamina**, giving structural support to the nuclear envelope.



General functions of cytoskeleton:

1. It plays an important role in intracellular transport, e.g. the movement of vesicles.
2. It maintains the shape of the cell.
3. It involves the movement of the cell in its environment.
4. It plays an important role of cell division.
5. It anchors the cellular organelles in position
6. It forms structures such as flagella and cilia
7. It assists the contraction of muscle cells.
8. It supports the cell.

Continues …