The cellular level of organisation

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The Cell

Defination - “A cell is defined as the smallest, basic unit of life that is responsible for all of life’s processes, enclosed by membrane.” A cell can replicate itself independently. Hence, they are known as the building blocks of life.

- A human body may have as many as 10^{14} cells and avg. diameter of the cell is approximately 10um(10^{-5}m).

Cytology: It is the branch of science concern with the study of cells.

- Cells are the smallest functional units of the body. They are grouped together to form tissues, each of which has a specialized function, e.g. blood, muscle, bone.

- Different tissues are grouped together to form organs, e.g. heart, stomach, brain.
- Organs are grouped together to form systems, each of which performs a particular function that maintains homeostasis and contributes to the health of the individual.
- For example, the digestive system is responsible for taking in, digesting and absorbing food and involves a number of organs, including the stomach and intestines, pancreas, liver.
- Individual cells are too small to be not seen with the naked eye. However, they can be seen when thin slices of tissue are stained in the laboratory and magnified by a microscope.

Structure and function

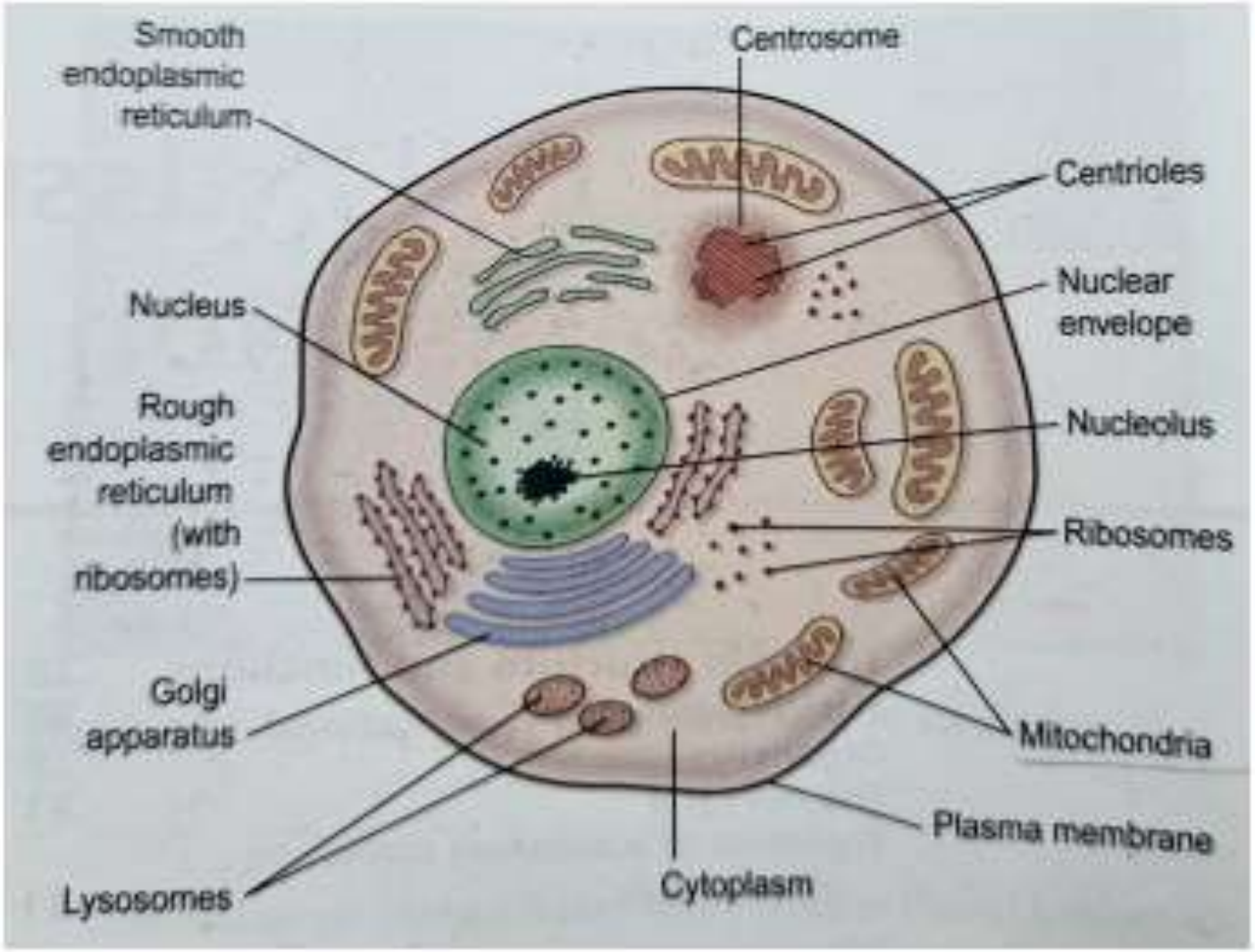


Fig.- The cell

Parts of the cells:

Plasma membrane

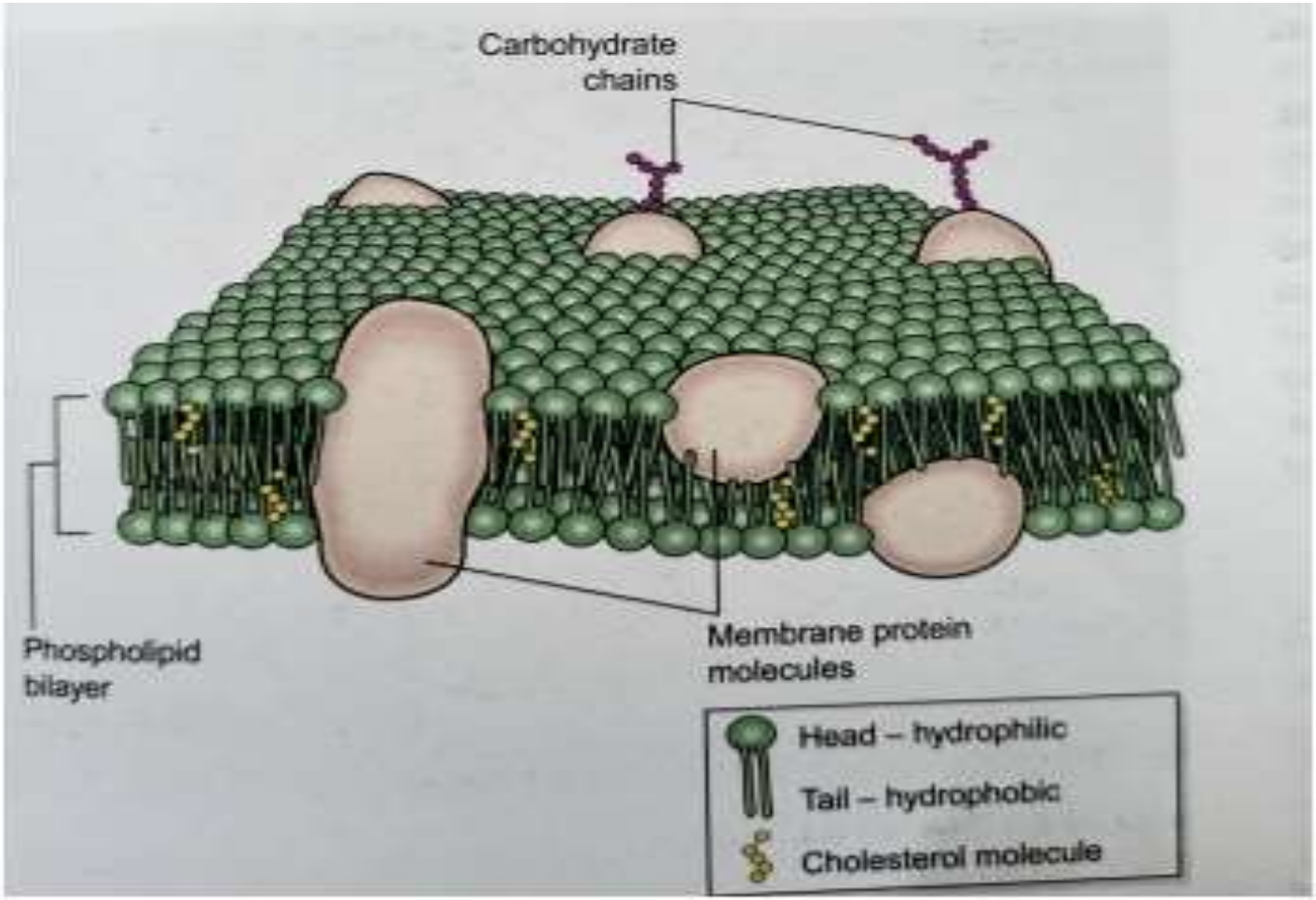


Fig.- The plasma membrane

Plasma membrane

- It is the outer envelope of the cell. Which is thin and elastic consists of two layer of phospholipids with protein and sugar molecule embedded in them.
- In addition to phospholipids the lipid cholesterol is also present in the plasma membrane
- The protein molecule present in the plasma membrane provide channels that allow the passage of electrolytes, non-lipid soluble substances.
- Phospholipid molecule have head - which is hydrophilic in nature and a tail - which has hydrophobic in nature.
- It consist 50:50 mix by weight of protein and lipids
- In plasma membrane protein are large molecules than the lipid. So one protein molecules surrounded by around 50 lipids molecules.

- The plasma membrane is made up by lipid bilayer.
- It consist three types of lipids.

A) lipid bilayer.

Phospholipids: 75% of membrane lipids are phospholipids. It contains phosphate groups.

Cholesterol: 20% of membrane lipids are cholesterol. Which is a steroid attached with –OH group.

Glycolipids: 5% of membrane lipids are glycolipids. Attached with carbohydrate groups.

- The lipid bilayer is amphipathic because it consist both polar and non polar parts.
- In phospholipids, the polar part is the phosphate containing head which is hydrophilic (water loving).

- The non polar part contains two long fatty acid tails which are hydrophobic (water hating) hydrocarbon chains.
- Cholesterol molecules are weakly amphipathic.
- In glycolipids carbohydrate groups act head as polar group while their fatty tail act as non polar group.

B) Membrane proteins:

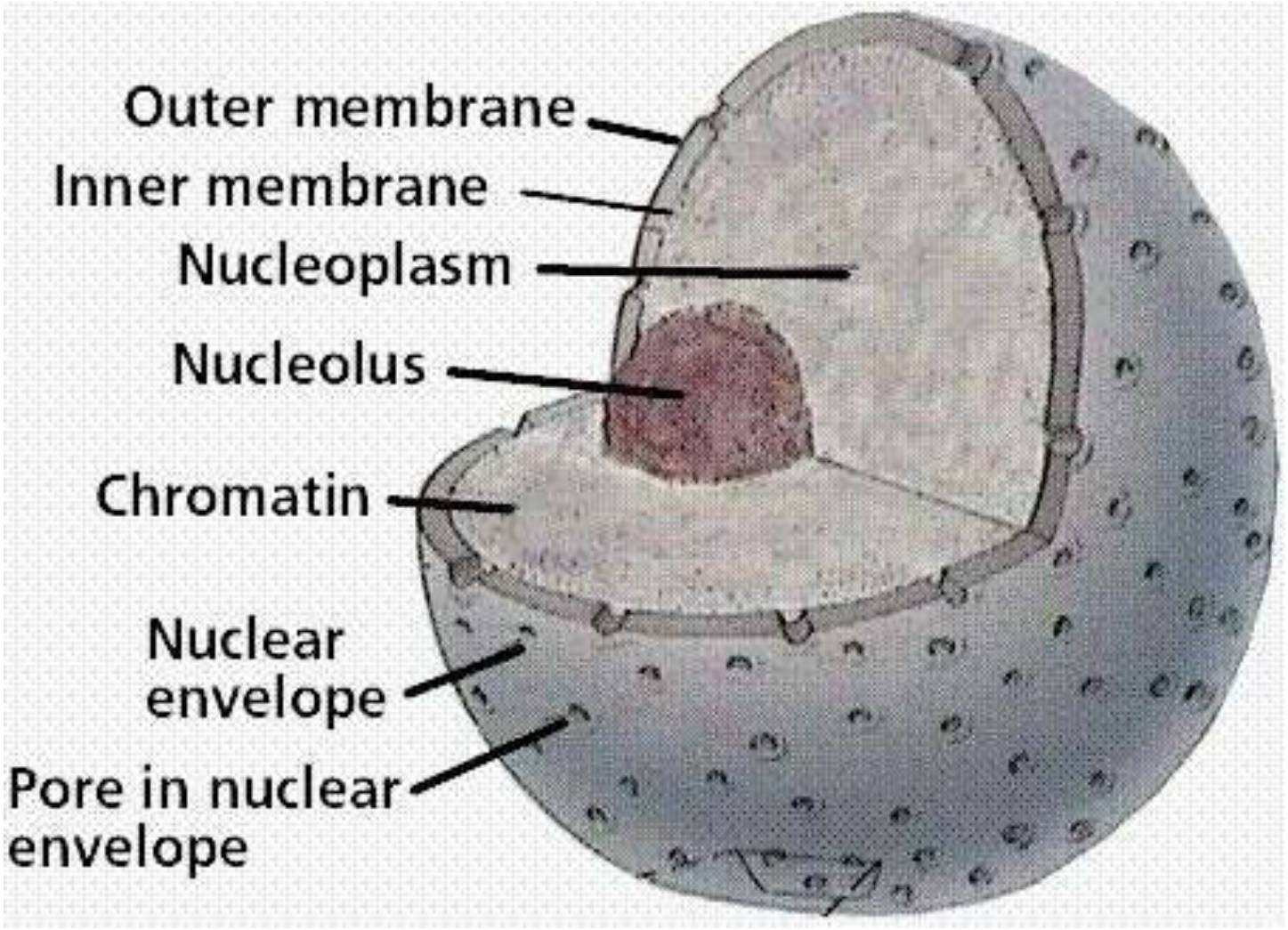
- Plasma membrane consist two types of proteins

a) **Integrated proteins:**

- Most of integral proteins are glycoprotein, it is attached with sugar groups.
- The portion of the attaché sugar group faces the extracellular fluids.

b) Peripheral proteins: They are loosely attached to the inner and outer surface of the membrane and are easily separated from it.

Nucleus


Outer membrane
Inner membrane
Nucleoplasm
Nucleolus
Chromatin
Nuclear envelope
Pore in nuclear envelope

- Every cell in the body has nucleus with exception of mature (RBCs) erythrocytes.
- Skeletal muscle and some other cells contain several nuclei.
- Nucleus contain nuclear envelop (Similar to plasma membrane). They contain some tiny pore through which some substance can pass between it and the cytoplasm.
- Nucleus contain the body genetic material which directs all the metabolic activities of the cell
- This consists of 46 chromosomes which are made up of DNA except during cell division the chromosomes resemble a fine network of threads called chromatin.
- The gel-like matrix in which the nuclear components are suspended is the nucleoplasm.

- Thus the nucleus stores the cell hereditary material DNA and it coordinates the cells activities, which include growth, metabolism, protein synthesis, and cell division.

CYTOPLASM

- It consist all the cellular contains between plasma membrane and nucleus.
- It consist two components:

1) Cytosol:

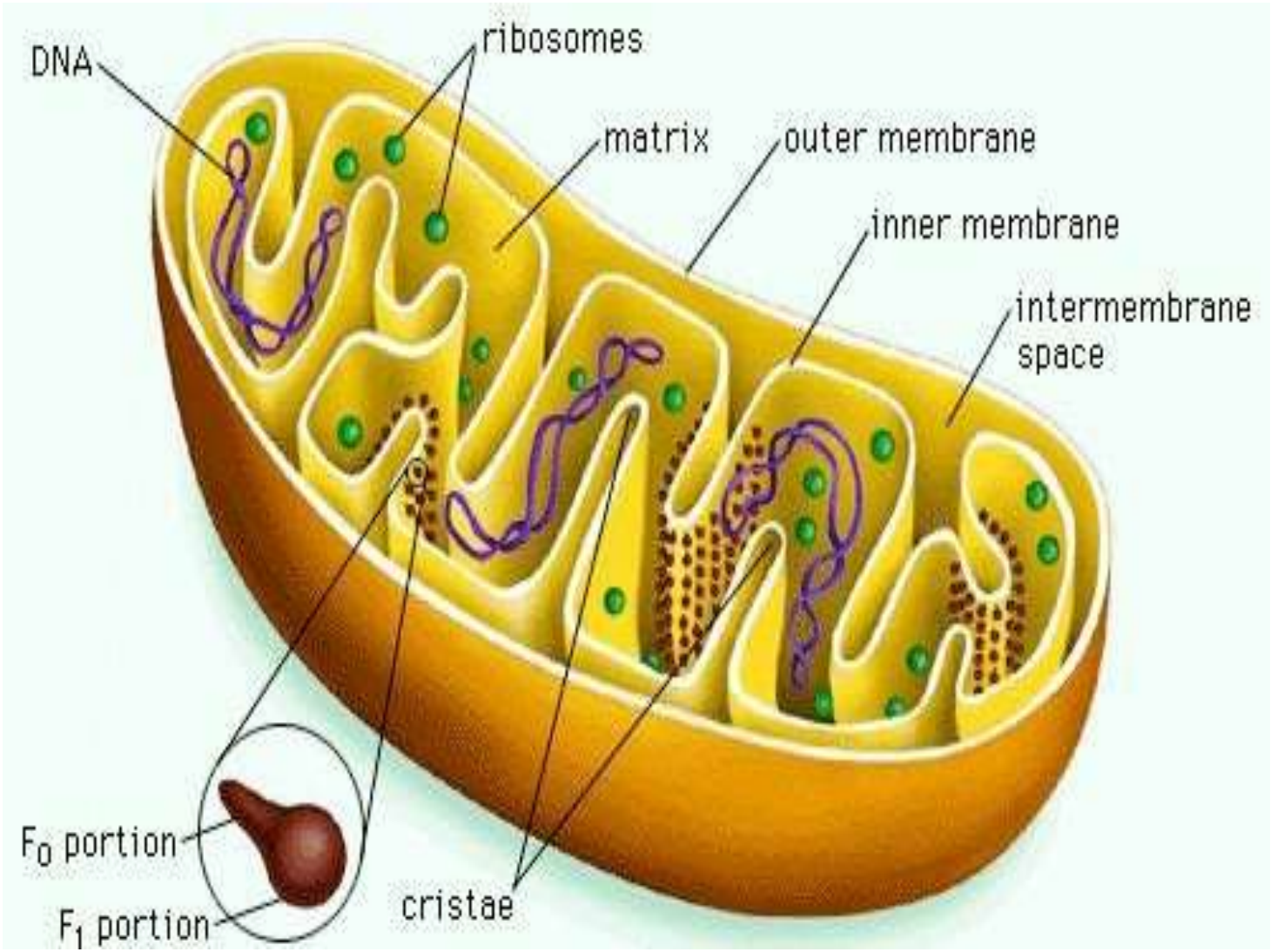
- It is the unsaturated soluble portion of the cells.
- Chemically it is 75-90 % water plus solid components (protein, carbohydrate, lipids and inorganic substance).
- Inorganic substance and smaller organic substance such as simple sugar and amino acid are soluble in water and are present as solute.

- While larger particle such as protein and polysaccharide glycogen found as colloidal particle in surrounding medium and they are not dissolved.
- The cytosol receives raw material from the external environment and gain usable energy from them by decomposition reaction.

2) Organelles

- These are specialized structures that have characteristics appearance and specific role in growth, maintenance, repair and control.

Mitochondria:



- Mitochondria are the largest components of the cytoplasm.
- They are the power house of the cell and each cell may contain from 50 to 2500 mitochondria depending upon the respiratory activity of the cells.
- Eg: The cell of skeletal muscle, kidney and liver contain large number of mitochondria while heart muscles contain less.
- They are vary in shape and size (0.5 to 3μ long and 0.1 to 0.6μ wide).
- They have two membranes, the outer is smooth but the inner is arranged series of folds form ridges known as cristae.
- Mitochondria consist central cavity enclosed by inner membrane is known as matrix.
- Folds increase the inner surface area which useful for the cellular respiration.
- The matrix and cristae contains the catalytic enzyme (ATP synthetase enz.) which produce the ATP.

- The mitochondria contain large number of enzyme which are involved in:
- Oxidation of pyruvic acid in Kreb's cycle via acetyl CoA
- Electron transport and oxidative phosphorylation
- Synthesis of fatty acids.

Endoplasmic Reticulum:

- This is the complicated and organized system of membranes in the cytoplasm of the cell.
- This membrane is constituted of protein lipid double layer and is very well developed in tissue with active protein synthesis.
- There are two types of endoplasmic reticules one is rough or granular endoplasmic reticulum consist ribosomes on their surface and second is smooth endoplasmic reticulum or agranular which has no ribosomes.

Rough endoplasmic reticulum is associated with the protein synthesis.

- It serves as temporary storage area for newly synthesized molecules and may add sugar groups to certain proteins. Eg.: Glycoproteins.

Smooth endoplasmic reticulum is the site for fatty acids, phospholipids and steroidal synthesis.

- Enzyme within the smooth ER can inactive or detoxified a verity of chemicals including alcohols, pesticides, and carcinogens.

Ribosome:

- Ribosomes are tiny granules that contain ribosomal RNA (rRNA) and many ribosomal proteins.
- The size of the ribosomes ranges from 15 to 20 millimicrone and the diameter being 150Ao.
- The rRNA synthesized by DNA in nucleus.

- Functionally the ribosomes are the sites of protein synthesis.
- Some ribosomes are known as free ribosomes, float in cytosol. They are not attached to other organelles. Free ribosomes are form singly or in clustered form.
- Other ribosomes attached to a cellular structure called endoplasmic reticulum.

Golgi Complex:

- The golgi complex or apparatus is an organelles located near the nucleus.
- It consist flattened sac called cisterns which consists small Golgi vesicles.
- The Golgi complex packages protein into membrane – bound vesicles inside the cell and deliver proteins and lipids to plasma membrane and forms lysosomes and secretary vesicles.

- All the proteins are export from the cells by similar rout i.e ribosomes (site of protein synthesis) – rough endoplasmic reticulum cistern – transport vesicles – Golgi complex– secretary vesicles – release to exterior of the cells by exocytosis.
- As the proteins pass through the Golgi cistern, they are modified in various ways depending on their function and destination. Finally they enter to trans or exit cistern.
- The trans or exist cistern modified the protein in to vesicles.
- Some vesicles become seretory vesicles and discharge their contain in to the extracellular fluid by exocytosis process.

Lysosomes:

- Lysosomes are membrane enclosed vesicles that form in the Golgi complex.
- Lysosomes are also called ‘susidal bags of the cell’.
- Inside the lysosomes, there are as many as 40 kinds of powerful digestive (hydrolytic) enzymes capable of breaking down a wide variety of molecules.
- Lysosomes contain digestive enzymes, when cell die or after death these organelles burst and digest all othe organelles inside the cell.
- Some disorders are caused by faulty lysosomes.
- Eg.: Tay-Sachs disease is an inherited which is cause by absence of single lysosomes enzyme. This enzyme is essential for the break down of membrane glycolipids which is essential for to prevent the nerve cells function.

- In absence of this enzyme nerve cells get damage and produce blindness in child, demented, die usually before the age of 5.
- Lysosomes work best at acidic pH. The lysosomes membrane have active transport pump that drive hydrogen ion (H+) into the lysosomes. So the interior of a lysosomes has a pH 5, which is 100 times more acidic than the cytosolic pH of 7.
- Lysosomes digest the bacteria and other substance that enter the cell by phagocytosis or pinocytosis.
- Lysosomal enzymes may also destroy their own host cells called autolysis.
- Lysosomal enzymes may digest the cellular debris at the site of injury.

Peroxisomes:

- They are similar in structure to lysosomes but are smaller and contain several oxidases, enzymes that can oxidize (remove hydrogen atoms from) various organic substances.

- It contains one or more enzymes that are used in oxygen to oxidize process. Such reaction produces hydrogen peroxide.
- The oxidize toxic substances, such as alcohol in the liver cell.

The cytoskeleton: The cytoskeleton is a network if 3 types of protein filaments that extend throughout the cytosol-Microfilaments, intermediate filaments, and microtubules.

- Coordination of the cellular movements and cellular shape is maintained by the cytoskeleton.
- The cytoskeleton is responsible for the movement of whole cells, such as phagocytes and for movement of organelles and some chemicals within the cells.

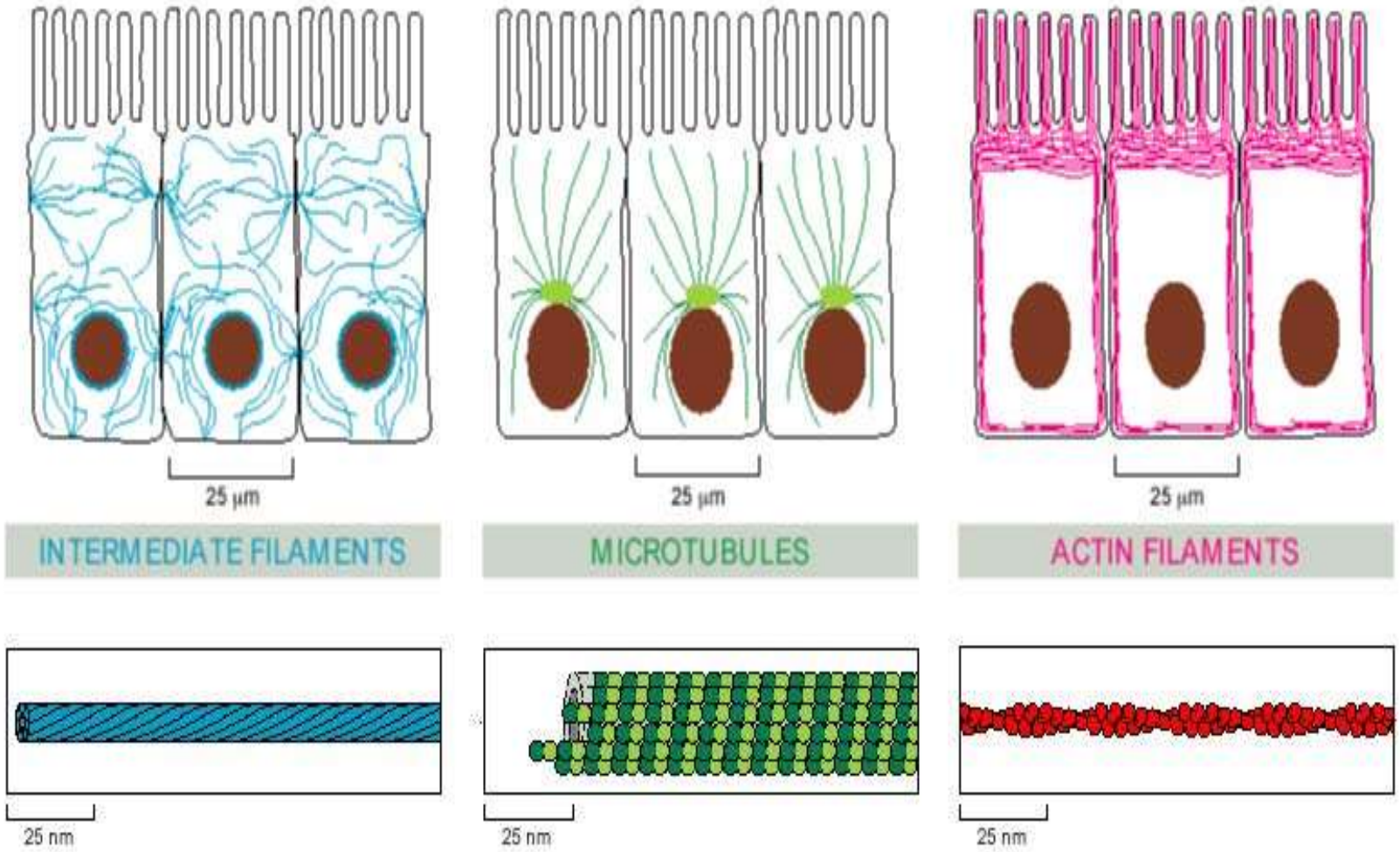


Fig. - **Cytoskeleton**

1. Microfilaments:

- It has rod like structures of varying length that are formed from the protein actin.
- **Function –** They help generate movement and provide mechanical support.
- They are involved in muscle contraction, cell division, and cell locomotion
- They provide mechanical support to microvilli(nonmotile microscopic figure like projection of the plasma membrane.)

2. Intermediate filaments:

- Intermediate filament are thicker than microfilament .
- It holds the organelles in their position and help attach cells to one another.

3. Microtubules:

- It is larger than microfilaments.
- They are relatively long, unbranched hollow tube that consist protein is known as tubulin.
- Microtubules also work as conveyer belt for the movement of various substances.

Centrioles

- The cell has a pair of cylindrical structure called centrioles. Which can be seen only when cell is dividing. It also forms the mitotic spindle during cell division.
- The two centrioles together form centrosome.
- Centriole of the centrosome is situated near the nucleus and play a very important role in cell division.

Function of cell

- Structural and functional unit of living body.
- Help in protein synthesis.
- Metabolism.
- Transportation.
- Defence mechanism.
- Genetic information.
- Movement of substance across the cell membrane.
- DNA replication.