

CYTOPLASMIC ORGANELLES

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❖ CYTOPLASMIC ORGANELLES

Cytoplasmic Organelles are classified according to the presence or absence of surrounding **membranes** into:

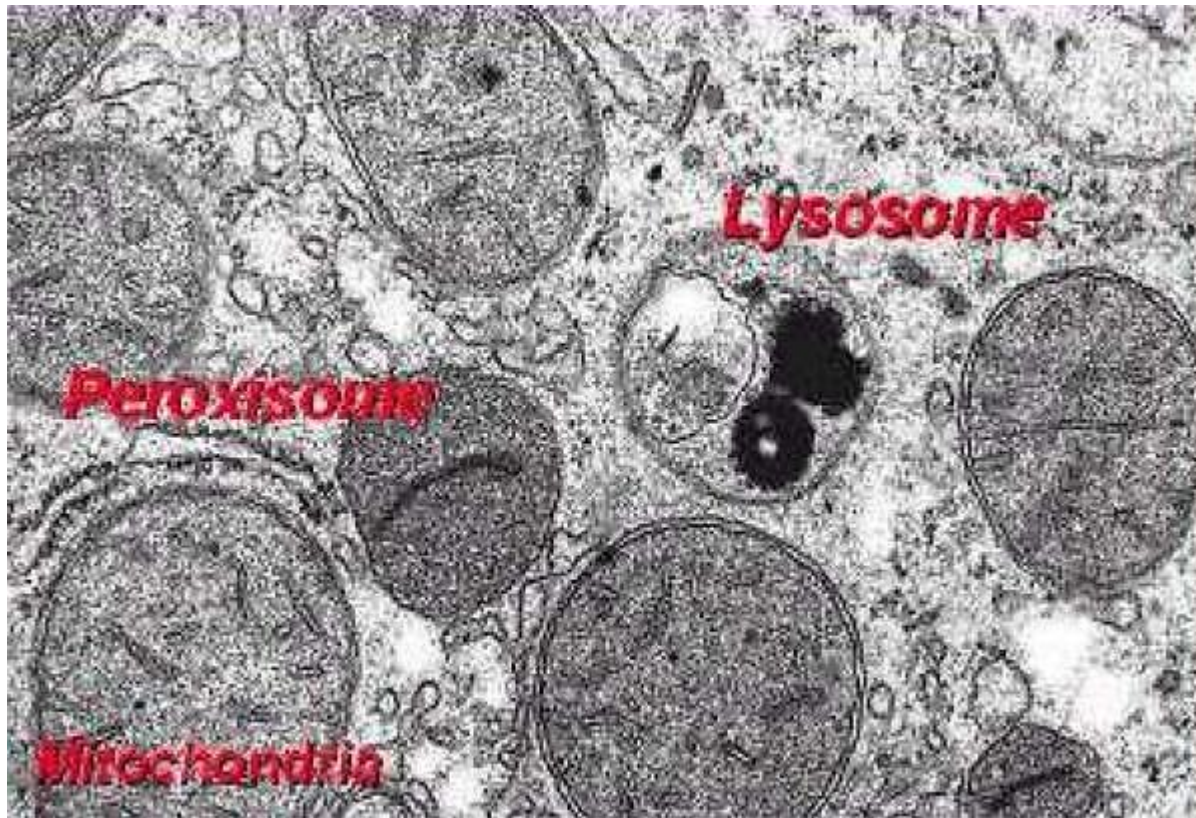
A-Membranous cell organelles:

- 1- Mitochondria
- 2- Endoplasmic reticulum (rough & smooth)
- 3- Golgi apparatus
- 4-Annulate lamellae
- 5- Membrane bounded vesicles.
 - a) Transport vesicles
 - b) secretory vesicles
 - c) Lysosomes
 - d) Peroxisomes
 - e) Endosomes

B-Non membranous cell organelles

- 1- Ribosomes
- 2- Proteasomes
- 3- Cytoskeleton:
 - a- Microtubules (centrioles and cilia).
 - b- Filaments (thin, and intermediate).

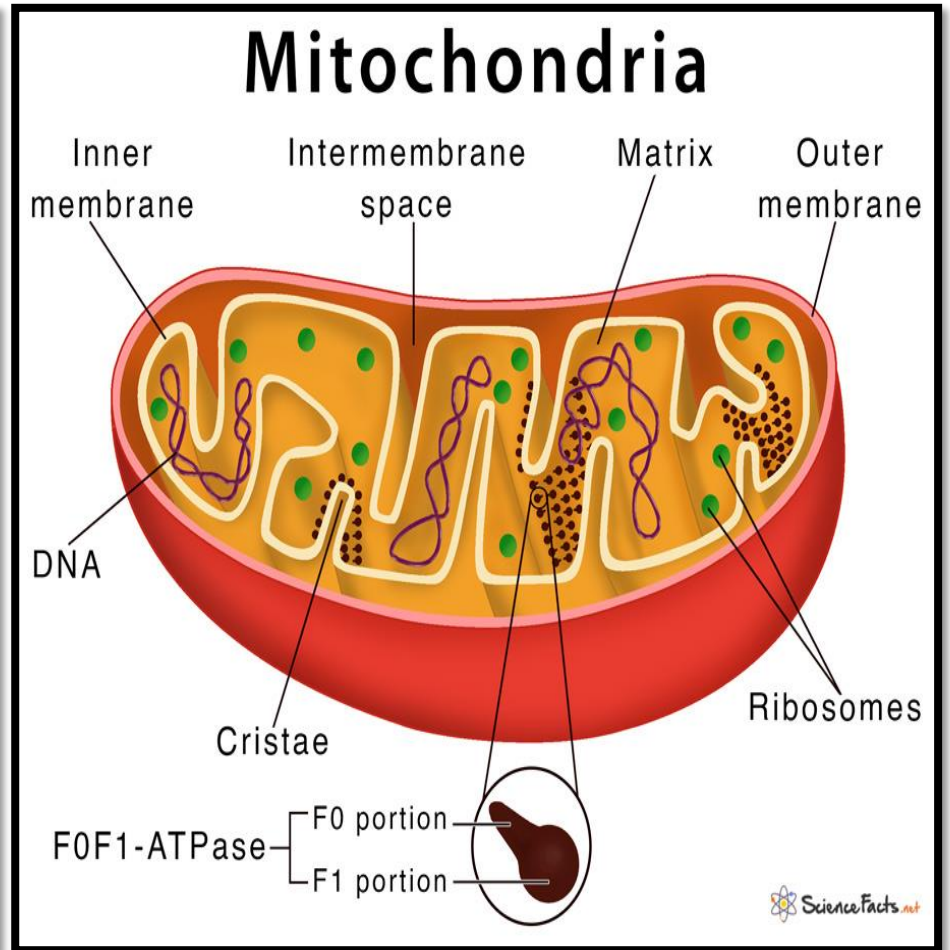
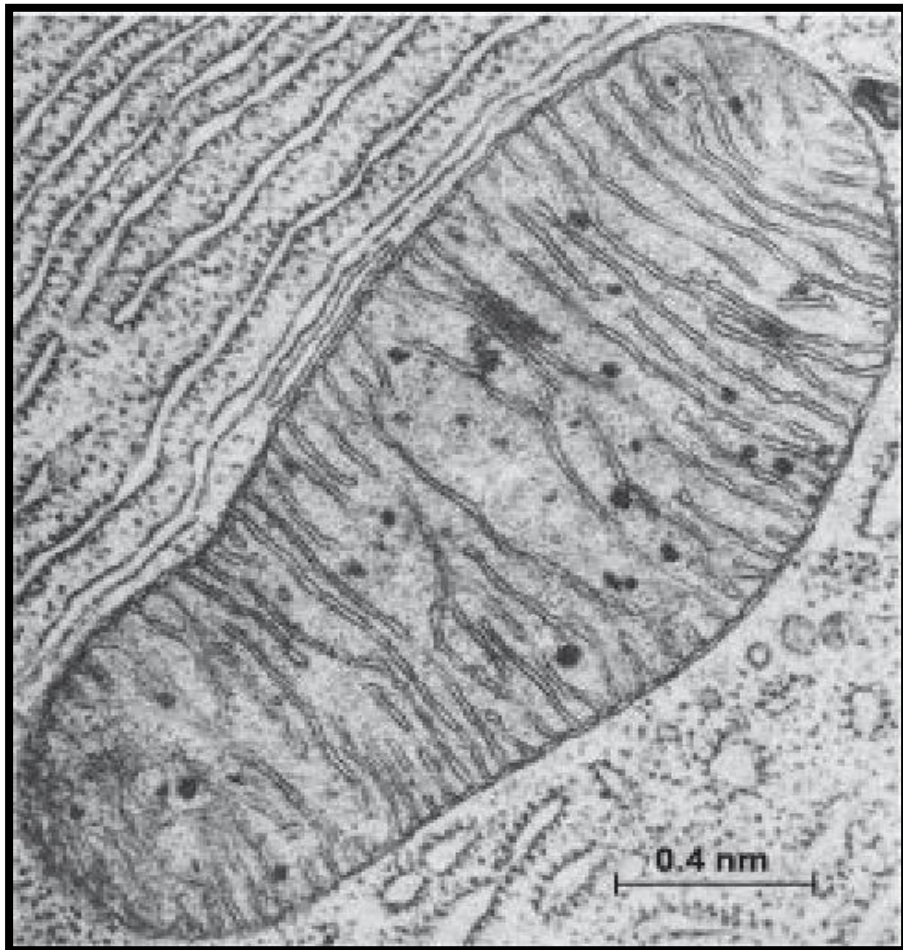
- N.B: The surrounding membrane (unit membrane) in these organelles is like a cell membrane, but differs from it as follows:
 - Less thickness than the cell membrane
 - Devoid of cell coat
 - Has different receptors



MITOCHONDRIA

- (Mitos = thread; chondrion = granule)
- Size: Their size, number, and shape are characteristic of each specific cell. The size of mitochondria ranges from 0.5 to 1 um in width and up to 10 um in length.
- Number: Their number is increased in cells of high metabolic activity e.g., liver cells (may reach 2000 in each liver cell).
- **L/M:** ▪ Mitochondria need special stains
 - a- **blue when stained with iron hematoxylin.**
 - b- **green when stained with Janus green B (supravital stain).**
- They appear as thread-like, rod-shaped, or granules.
- **H&E:** When present in large numbers, mitochondria contribute to the acidophilia of the cytoplasm because of the large amount of membrane they contain.

EM MITOCHONDRIA



- **E/M:**
- Each mitochondrion has outer and inner membranes (double) separated by an inter-membranous space.
- Each of the two mitochondrial membranes is a trilaminar unit membrane

Outer membrane:

- It is smooth and freely permeable to water, water soluble molecules, ions, and energy molecules (ATP and ADP).
- The mitochondrial outer membrane can associate with the endoplasmic reticulum (ER) membrane, in a structure called **MAM** (mitochondria associated ER-membrane).
- Mitochondria stripped of their outer membrane leaving the inner membrane intact are called **mitoplasts**.

Inner membrane:

- It is folded forming cristae that expand its surface area enhancing its ability to produce ATP.
- The number of cristae is directly related to the energy requirements of the cell e.g. mitochondria of cardiac muscle cells have more cristae than that of fat cells.
- Elementary particles (**F₀-F₁ or Oxysomes**) are club-shaped structures attached to the inner surface of the inner membrane.

Innermost compartment:

It is the large space enclosed by the inner membrane called matrix. The mitochondrial matrix is a dense fluid composed of:

1. Enzymes of Kreb's cycle (citric acid cycle).
2. Mitochondrial ribosomes, transfer RNA and messenger RNA.
3. Double-stranded mitochondrial circular DNA.
4. Few electron-dense granules consisting of Ca^{+2}

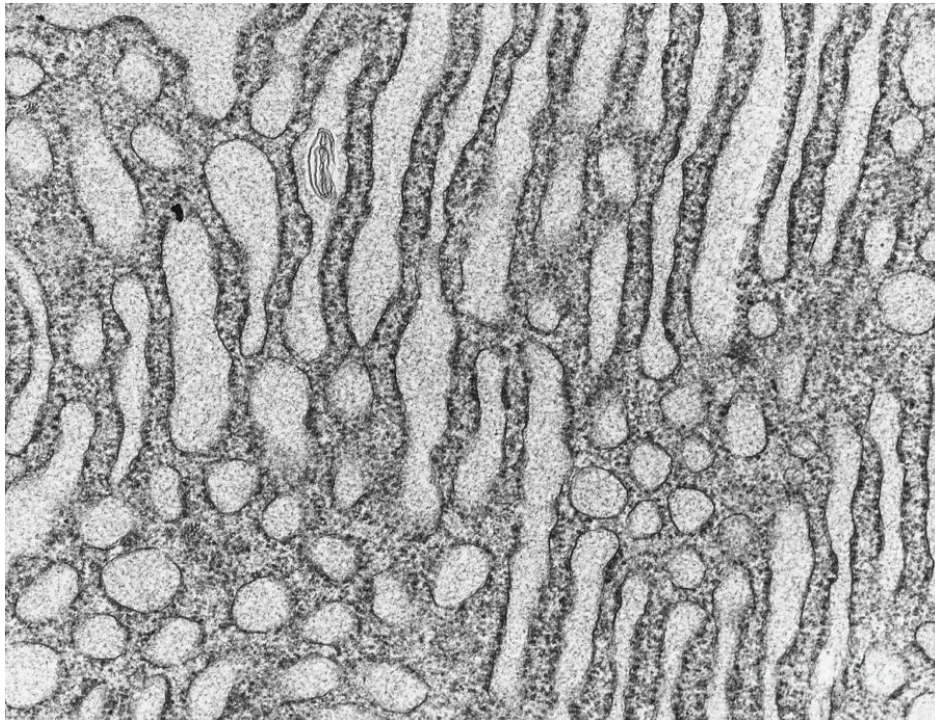
The functions of Mitochondria:

1. Production of energy as mitochondria are the power houses of the cell as they produce adenosine triphosphate (ATP).
2. Concentration of calcium in their matrix leads to calcium regulation within the cytoplasm.
3. Mitochondria have their own DNA & RNA, so they can synthesize a small proportion of their proteins (e.g. enzymes).
4. Mitochondria are self-replicating organelles, they increase in size, replicate their DNA, and undergo fission to get two mitochondria from a single mitochondrion

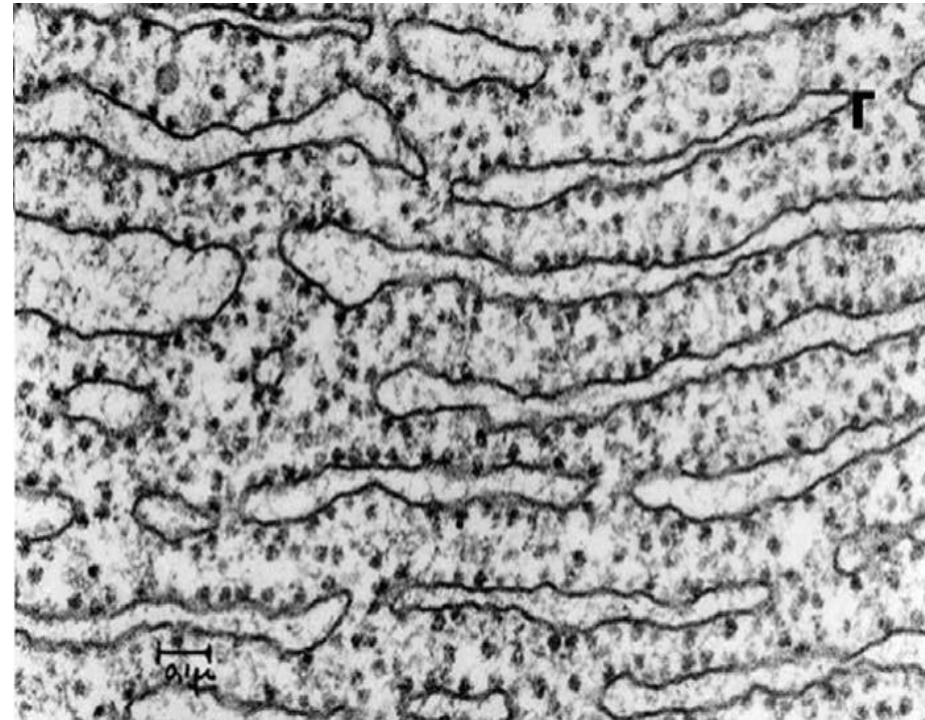
ENDOPLASMIC RETICULUM (ER)

- **Defintion:** It is a membranous organelle formed of tubules and sacs.
- **Types:** There are two forms of ER and both are continuous with each other:
 - a) Smooth endoplasmic reticulum (SER) without attached ribosomes.
 - b) Rough endoplasmic reticulum (RER) with attached ribosomes.

SER



RER



	Smooth Endoplasmic Reticulum (sER)	Rough Endoplasmic Reticulum (rER)
Site	Cells that synthesize cholesterol, lipid (e.g liver cells), and steroid hormones (e.g. endocrine cells).	Cells specialized for protein secretion, such as pancreatic cells, and plasma cells.
L.M H& E	It cannot be seen. If it is abundant the cytoplasm becomes acidophilic.	it causes a localized cytoplasmic basophilia due to the attached ribosomes and polyribosomes.
E.M	Smooth-surfaced network of anastomosing tubules without ribosomes on their membranes <ul style="list-style-type: none"> • Formed from rER after losing its ribosomes. 	<ul style="list-style-type: none"> • Sac-like stacks and flattened tubules called cisternae are limited by membranes • Its outer (cytosolic) surface is studded with ribosomes and polyribosomes

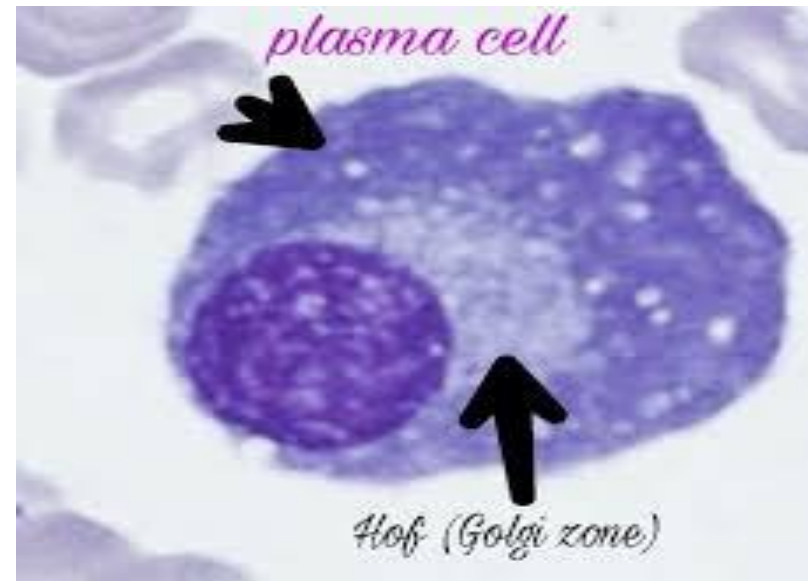
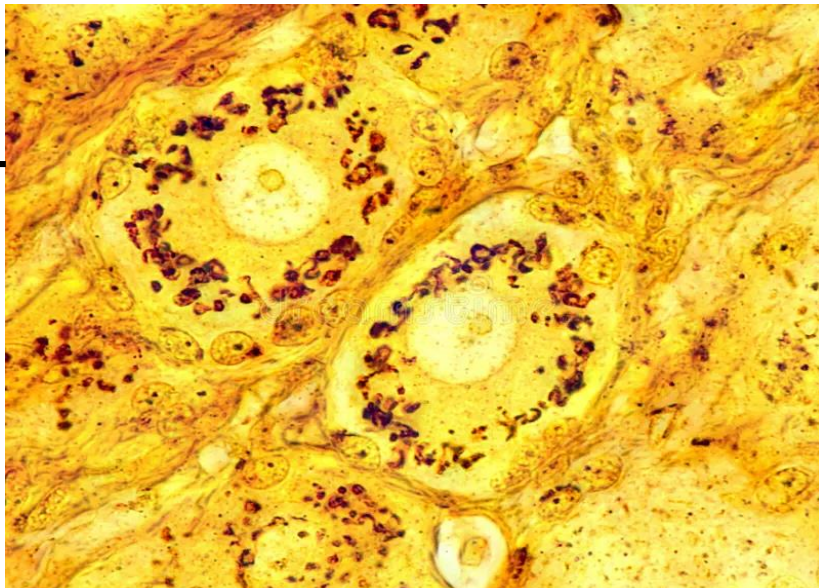
	Smooth Endoplasmic Reticulum (sER)	Rough Endoplasmic Reticulum (rER)
Function	<p>1. Steroid hormone synthesis e.g. adrenal gland.</p> <p>2. Formation & storage of glycogen e.g., in liver & muscles.</p> <p>3. It helps muscle contraction by a Ca pump.</p> <p>4. Detoxification of drugs & hormones in the liver. 6. Acts as an intracellular pathway.</p>	<p>1. RER synthesizes cellular proteins that are segregated from the cytosol. These proteins are:</p> <p>a- Secretory proteins (exported proteins).</p> <p>b- Lysosomal enzymes.</p> <p>c- Plasma membrane integral proteins.</p> <p>2. Renewal of immature face of Golgi.</p>

GOLGI COMPLEX (GOLGI APPARATUS)

- It is a membranous cell organelle that is well developed in secretory cells.
- **L/M:**

silver or osmium tetroxide: the Golgi apparatus appears as a darkly stained network located near the nucleus (Perinuclear- supranuclear).

H&E: in the intensely basophilic cytoplasm of plasma cells, the Golgi apparatus appears as a clear unstained area near the nucleus. This pale area is called the negative Golgi image, Hof or Golgi Ghost.



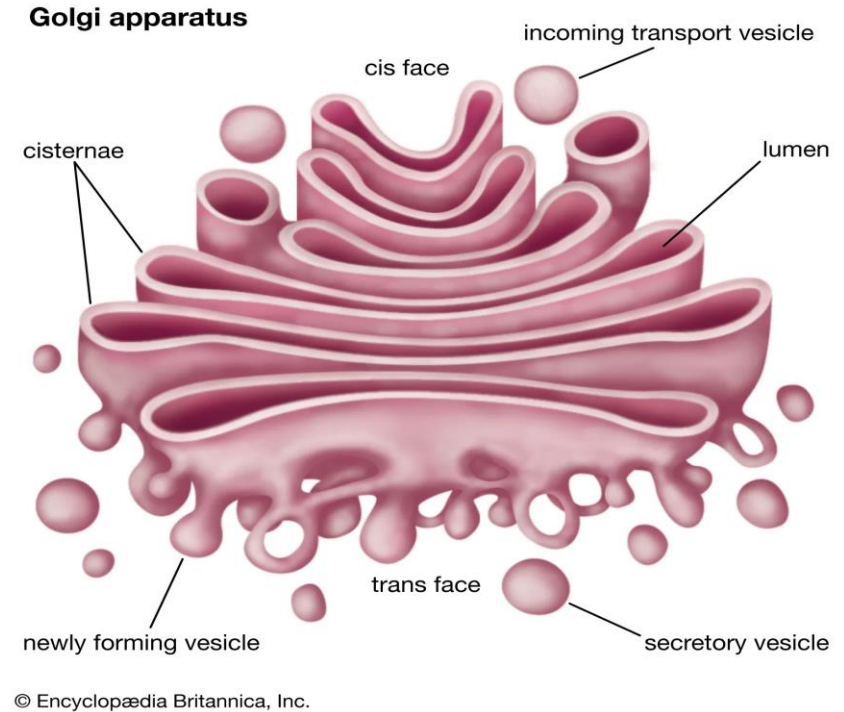
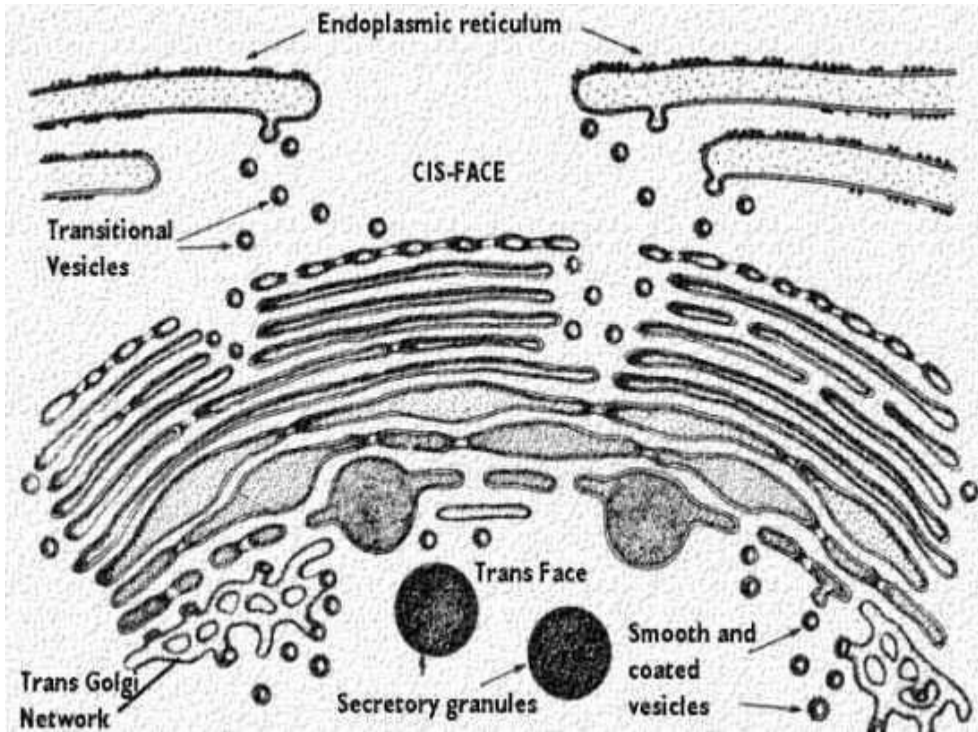
▪ **EM:**

Golgi apparatus is composed of :

I- Golgi stacks

II- Transport [transfer] vesicles

III- Condensing vacuoles and secretory vesicles



I- Golgi stack:

- It consists of slightly curved flat saccules (small sacs) or cisternae (3-12 in number). The periphery of each cisterna is dilated and surrounded by vesicles.
- The stack has **Cis-face** (immature or forming or receiving face) which is usually **convex**. It is directed towards the **rough endoplasmic reticulum** near the nucleus. **Trans-face** (mature or secretory or shipping face) is usually **concave** and is directed towards the **plasmalemma**. Its lumen is wider than that of Cis's face.
- between the cis face and the trans face there are flattened curved cisternae. The secretory products are moved through the stack (from cis-face to the trans-face) by vesicles budding off from one cisterna and fusing with the next in the stack.

II- Transport [transfer] vesicles: ▪ They are small in diameter.
▪ They pinch off from rER, migrate to the cis-face of Golgi apparatus, and fuse with its dilated rim. ▪ They carry newly synthesized polypeptides formed in RER.

III- Condensing vacuoles and secretory vesicles: ▪ They are large in diameter. ▪ They arise from the periphery of the trans-face of Golgi stacks. ▪ The fate of secretory granules will be either;

a) Fusing with the cell membrane and releasing their contents to the exterior of the cell (exocytosis).

b) Remaining inside the cell forming primary lysosomes.

▪ **The functions of the Golgi apparatus:**

1- Concentration of the protein formed by rER.

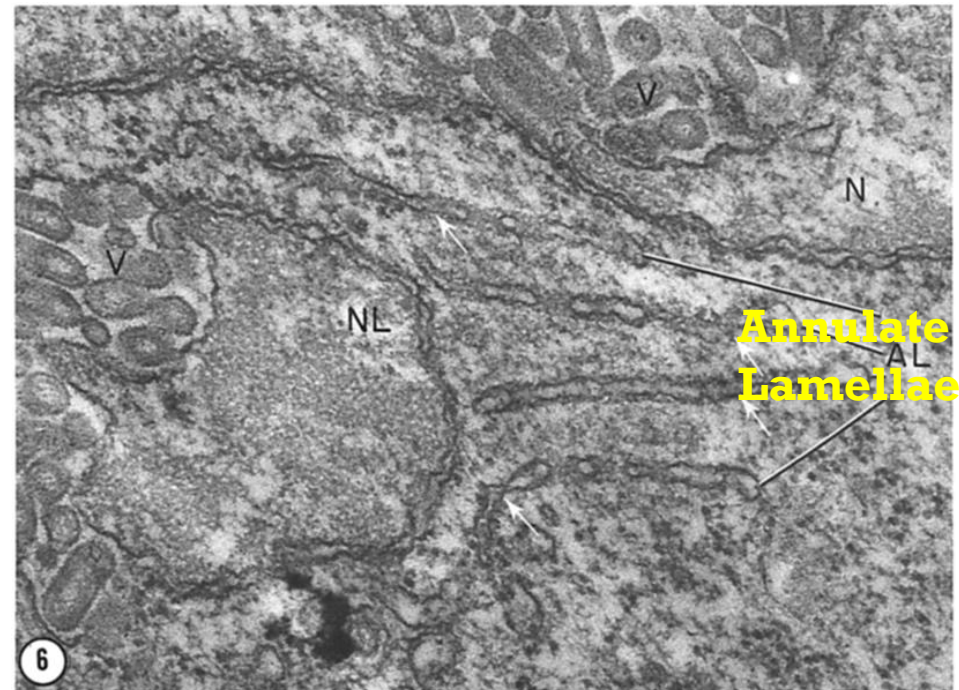
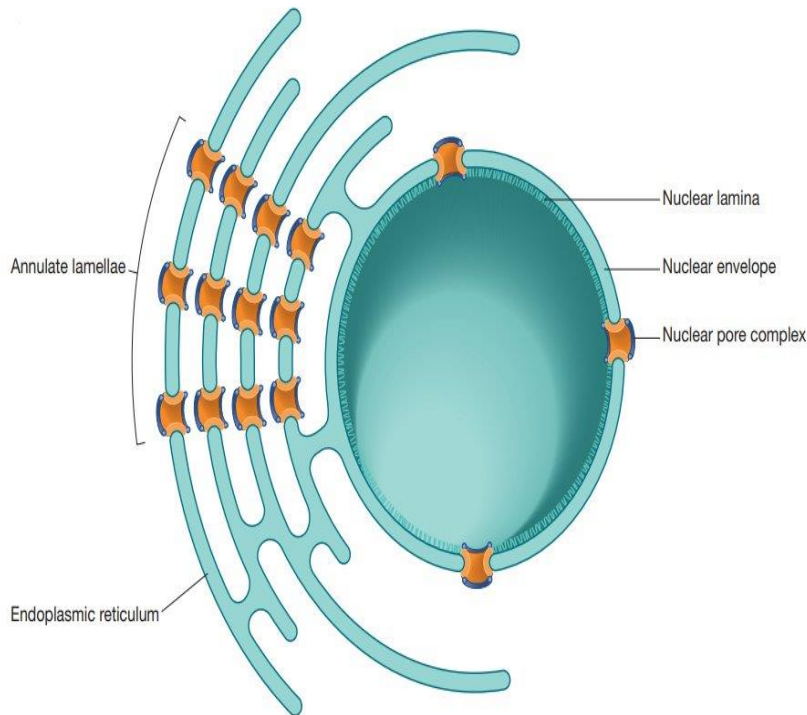
2- Modification of protein by adding sulfates or carbohydrates.

3- Sorting and discharge of secretion in the form of secretory vesicles.

4- Isolation and package of hydrolytic enzymes in the form of Lysosome

Annulate Lamellae:

- They are parallel membranes or cisternae. They resemble multiple copies (6-10) of nuclear envelopes. They act as reserves for the nuclear envelope.
- These organelles are present only in cells with high mitotic activity e.g. embryonic cells, and tumor cells.



❖ A-MEMBRANOUS CELL ORGANELLES:

1- Mitochondria

2- Endoplasmic reticulum (rough & smooth)

3- Golgi apparatus

4-Annulate lamellae

5- Membrane bounded vesicles.

a) Transport vesicles

b) secretory vesicles

c) Lysosomes

d) Peroxisomes

e) Endosomes

LYSOSOMES

- **Definition:** Lysosomes are membranous cell organelles consisting of vesicles filled with hydrolytic enzymes that can destroy unwanted material present within a cell.
- They are considered the digestive system of the cell.
- **Origin of lysosomal enzymes:** They are synthesized in rER and transported in vesicles to the Golgi complex. Sorting of lysosomal enzymes occurs also in the Golgi apparatus.
- **Contents:** Lysosomes contain hydrolytic digestive enzymes called hydrolases e.g acid phosphatase, proteases, nucleases, and lipases. The lysosomal enzymes have optimal activity at pH 5.
- **Site:** They are numerous in phagocytic cells e.g. macrophages, neutrophils, and osteoclasts.

■ **Histological Structure:**

LM: They can be demonstrated by using special histochemical stains for the enzymes present within them, e.g. acid phosphates enzyme.

EM: They are spherical small membranous vesicles and their appearance depends on their types.

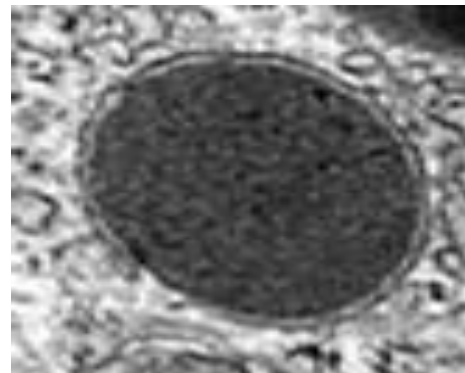
■ **Size:** Range in diameter from 0.05 μm to 0.5 μm .

■ **Types of lysosomes:**

1- Primary Lysosomes:

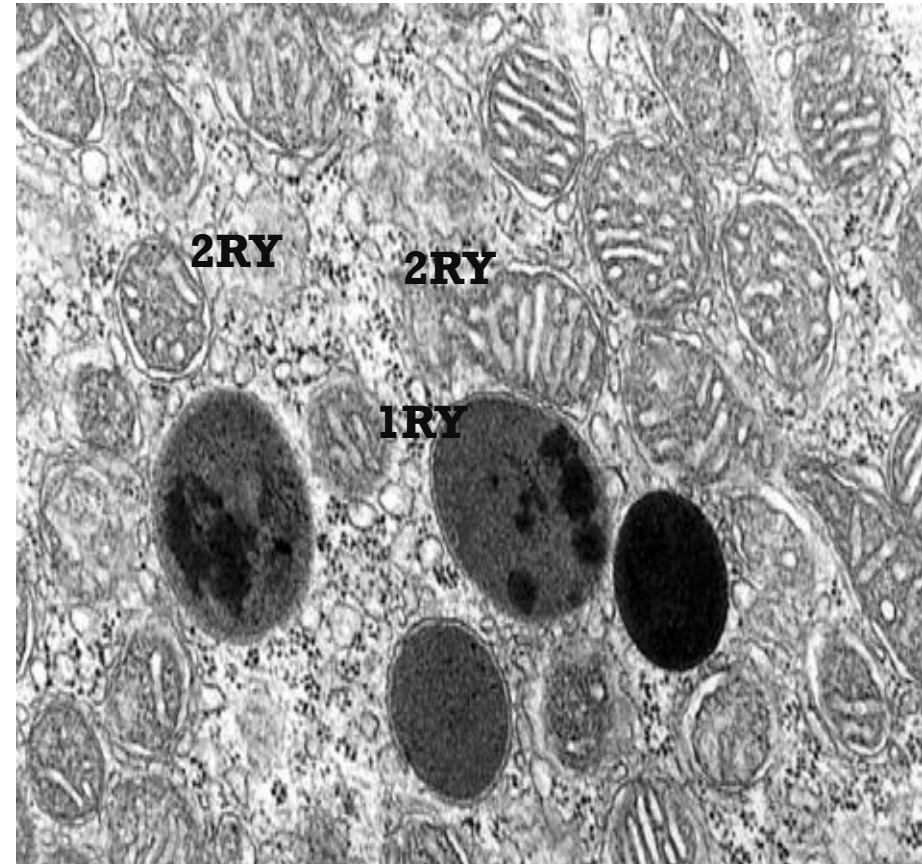
- They are newly formed lysosomes that have pinched off from the trans-face (mature face) of the Golgi apparatus and do not enter into digestive events.

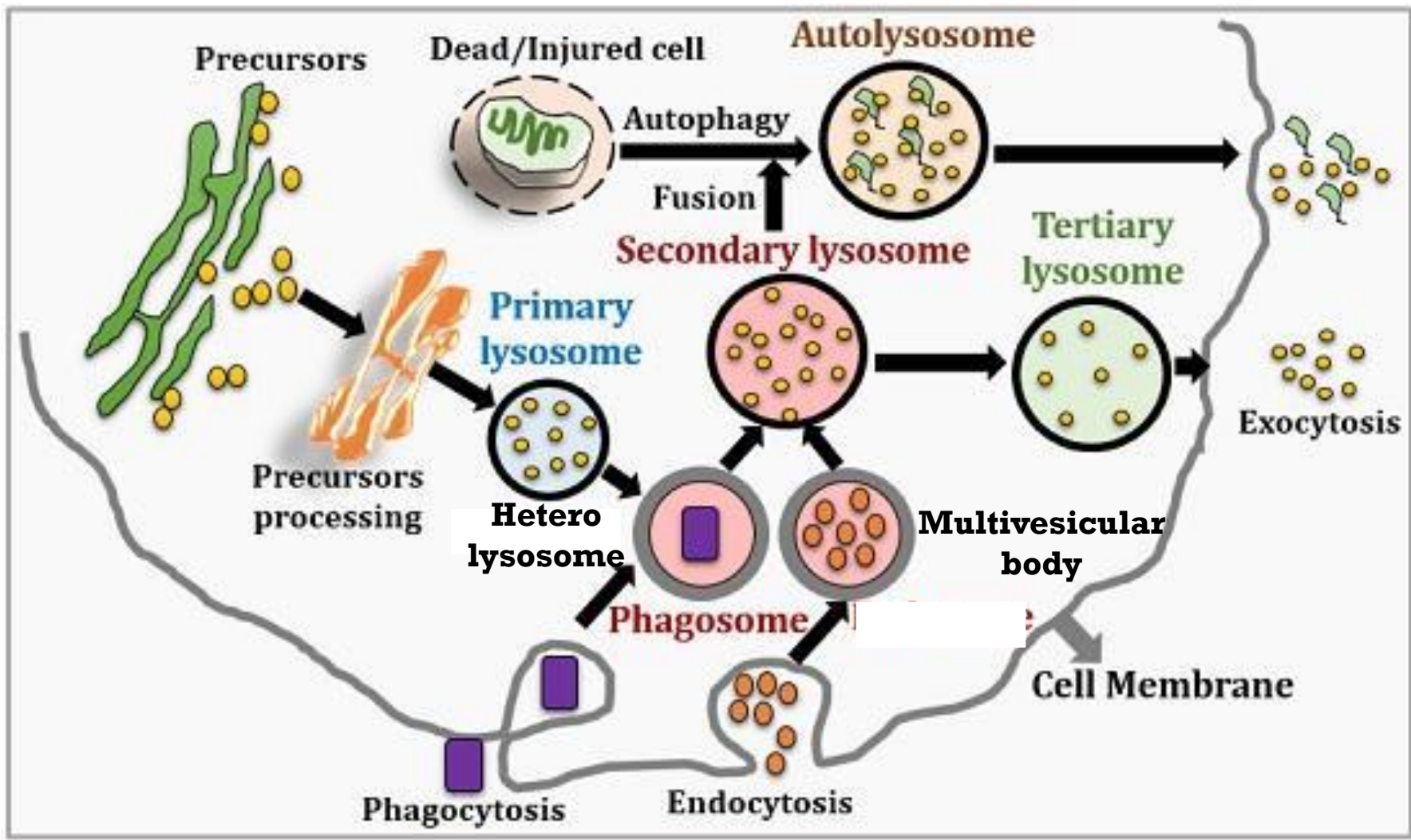
- They are homogenous when seen by transmission electron microscope.



2- Secondary Lysosomes:

- They result from the fusion of primary lysosome with phagocytic vesicle either from within or outside the cells.
- They are heterogonous vesicles when seen by transmission electron microscope.
- In secondary lysosomes enzymatic digestion breaks down the contents into small molecules that pass back across the lysosomal membranes, into the cytoplasm.
- They are of different types:
 - a) Heterolysosome
 - b) Multivesicular bodies
 - c) Autolysosomes





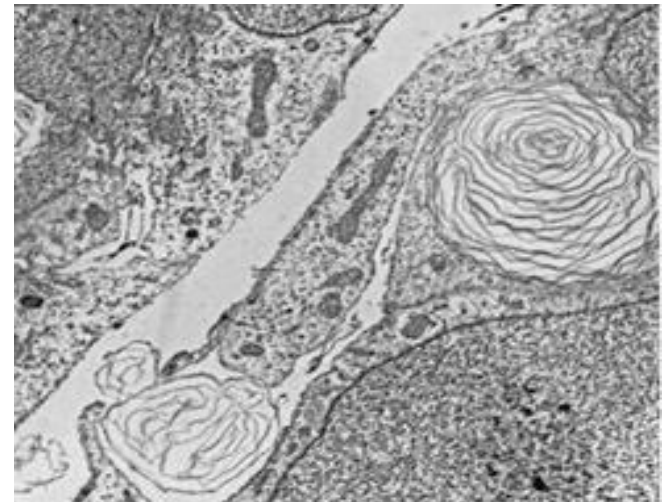
FORMATION AND POLYMORPHISM OF LYSOSOME

- a) **Heterolysosome:** It results from the fusion of a primary lysosome with a phagocytic vesicle containing food or bacteria (Heterophagy).
- b) **Multivesicular bodies:** They result from the fusion of primary lysosomes with pinocytotic vesicle containing fluid droplets.
- c) **Autolysosomes:** They result from the fusion of primary lysosomes with vacuoles containing old organelles (Autophagy).

3- Tertiary Lysosomes (Residual bodies):

The oldest lysosomes which are prominent in long-lived cells such as nerve and cardiac muscle cells. They often have bizarre shapes and are almost filled with debris, including concentric lamellae, indigestible material, and crystalline deposits.

They often accumulate lipofuscin pigment, or are released by exocytosis.



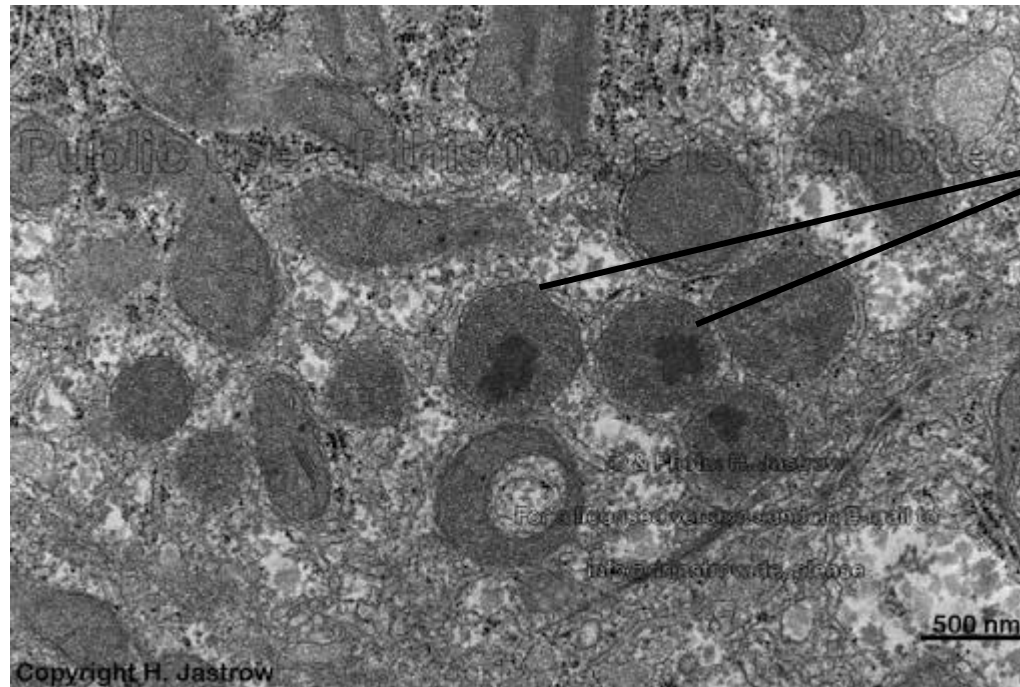
■ **Functions of lysosomes:**

- 1- Digestion of materials originated from outside and inside the cell.
- 2- Defensive function, destruction of any bacteria or virus.
- 3- Removal of any degenerated old organelles.
- 4- Lysis of the cells and all bodies after death.
- 5- Change inactive hormone into an active one. e.g., in the thyroid gland.

ENDOSOMES: They are **membranous organelles** that store materials before reaching the lysosomes. They have H⁺ pumps to acidify their interior.

PEROXISOMES (Microbodies):

- They are **membranous organelles** like lysosomes but differ from them in the type and function of their enzymes (**long-chain fatty acids oxidative enzymes**).
- In some animal species, peroxisomes have a denser central region called the nucleoid, which contains a crystal of urate oxidase. Their enzymes react with other substances to form hydrogen peroxide (**H₂O₂**), which is used to detoxify various substances



PEROXISOMES

RIBOSOMES

- Ribosomes are **non-membranous cell organelles**.
- **Sites:** They are present in all cells especially rapidly growing cell.
- **Site of their formation:** They are formed in nucleolus and then pass to the cytoplasm to perform their functions.

- **Types:**

1-Free ribosomes are scattered in the cytoplasm

2-Attached ribosomes are attached to the rough endoplasmic reticulum (rER)

3- Ribosomes also appear in small groups held together by a fine thread of mRNA forming polysomes

- **Structure:** Ribosomes consist of:

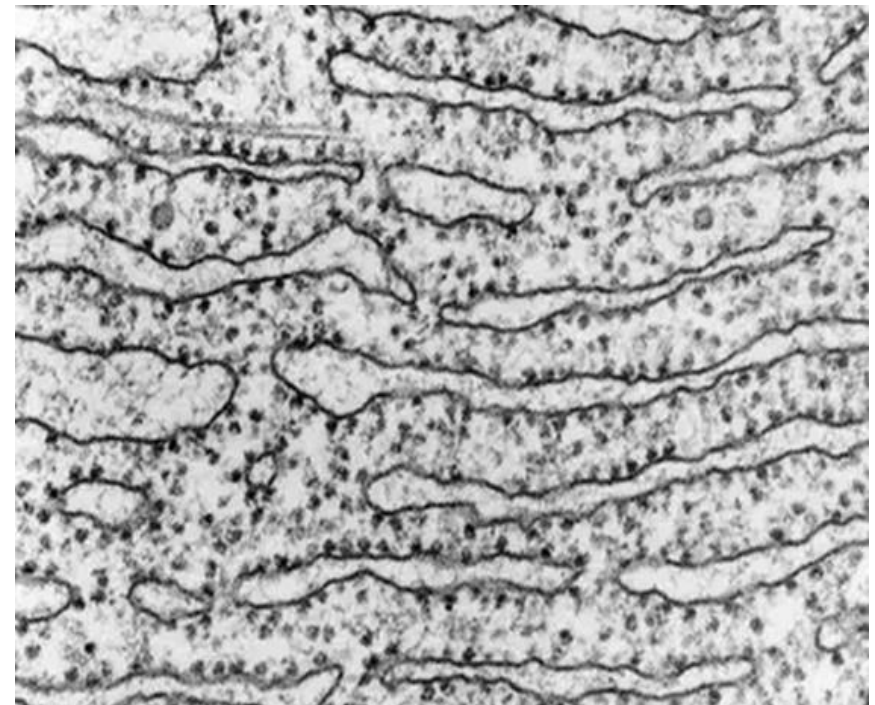
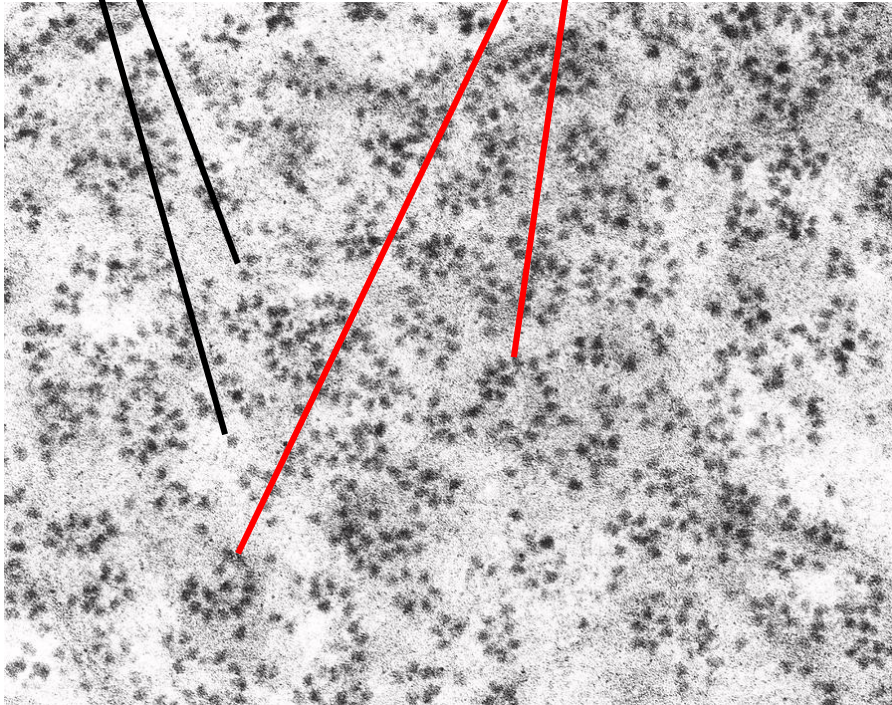
- a) Two thirds ribosomal ribonucleic acid (rRNA).
- b) One third proteins.

TYPES OF RIBOSOMES

Free

polosomes

Attached to RER



L/M:

- **H&E:** ribosomes appear basophilic due to their content of rRNA.

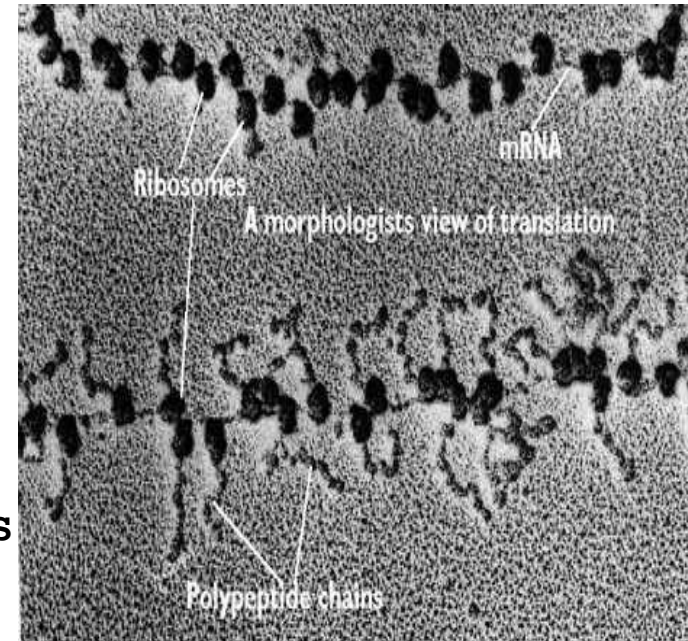
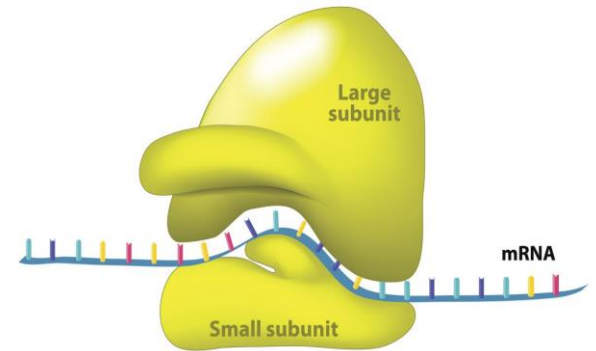
E/M:

- Low magnification:** ribosomes appear as small electron dense particles of about 15 nm
- High magnification:** shows that each ribosome consists of two subunits: Small subunit & Large subunit

Functions:

- 1) Protein synthesis with the aid of m-RNA and t-RNA.
- 2) Free ribosomes are responsible for synthesis of structural proteins for internal use of the cell.
- 3) Attached ribosomes are responsible for synthesis and segregation of protein which may be:
 - a) Secretory proteins.
 - b) Plasmalemmal
 - c) Lysosomal enzymes. proteins.

RIBOSOME



PROTEASOMES

- **Definition:** Proteasomes are **non-membranous organelles** that are very small in size.
- **Function:** is a degradation of proteins. They destroy damaged misfolded or unwanted proteins that have been labeled for destruction with ubiquitin without the involvement of lysosomes.
- Proteases are the enzymes that help in such a reaction

Thank You

