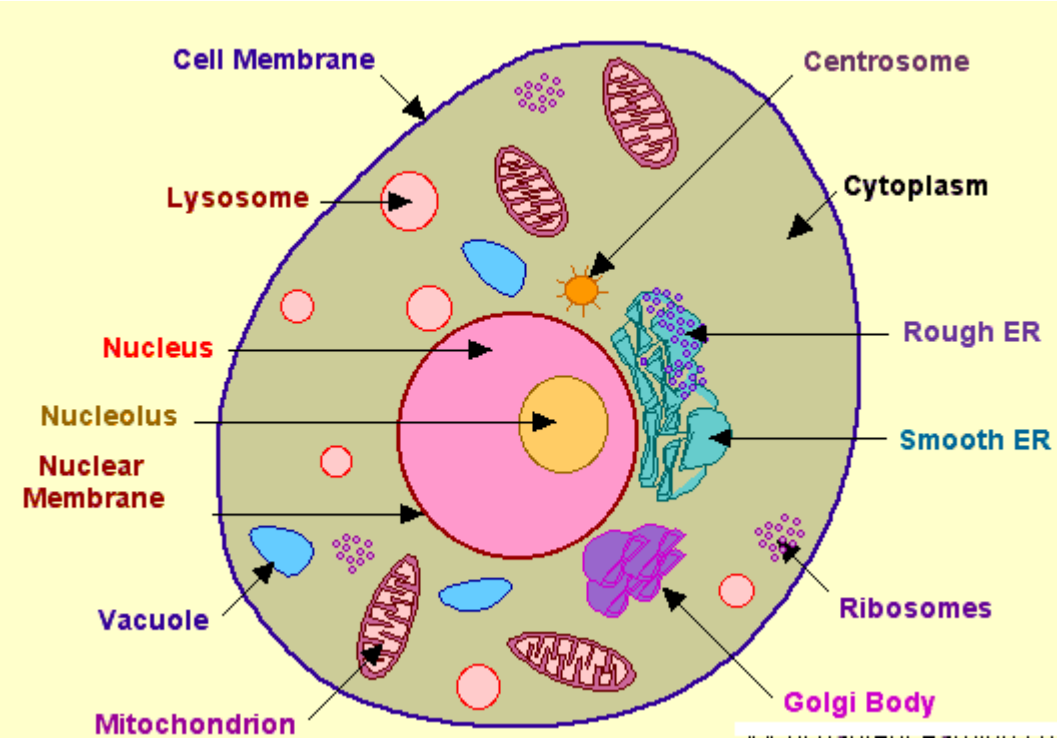
Medical Biology

Lec 3
Dr. Khalida Ibrahim

Cytoplasm

Cytoplasm is a watery environment inside the cell. Cytoplasm includes salts, an assortment of organic molecules, including many enzymes that catalyze reactions, as well as water.
One of the most interesting features of cytoplasm is its ability to change from a liquid (or sol) state to semisolid (or gel) state. This transition is brought about by polymerization of microtubules, microfilaments, and other elements of the protoplasm cytoskeleton. Cytoplasmic matrix fills the space between the plasma membrane and the internally located nucleus and is composed of a highly organized complex meshwork of elongated protein molecules responsible for many of the cell functions. Within the matrix are located the endoplasmic reticulum, mitochondria, Golgi apparatus, centrosome, and other cell organelles.

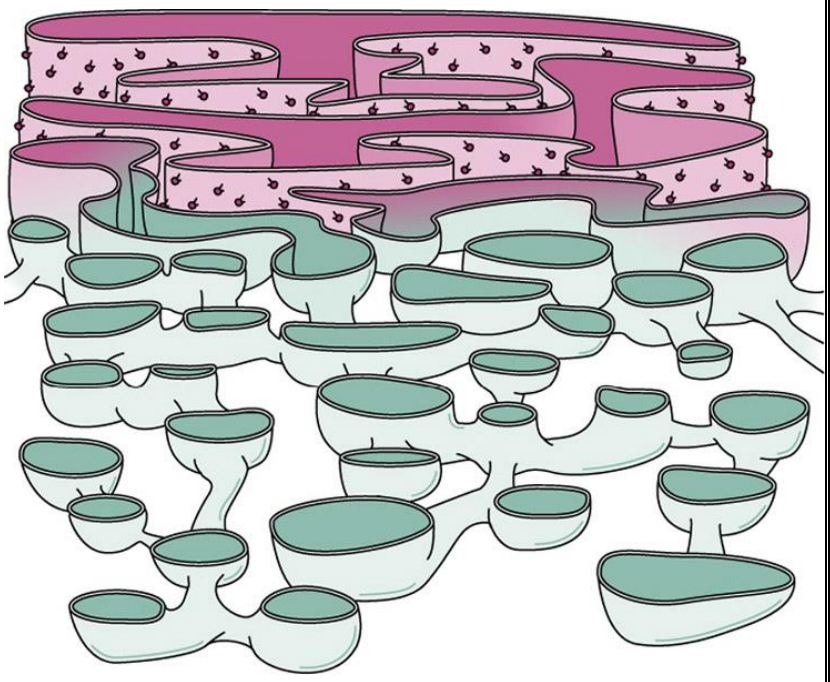


Cytoplasmic organelles:
All cells have the same basic set of intracellular organelles, which can be classified into two groups :
1. Membranous organelles with plasma membranes that separate the internal environment of the organelle from the cytoplasm .
2. Non membranous organelles without plasma membranes .

 The membranes of membranous organelles form vesicular, tubular, and other structural patterns within the cytoplasm that may be convoluted ملتويـة (as in smooth surfaced endoplasmic reticulum) or plicated مطويـة (as in the inner mitochondrial membrane).
 In addition, each type of organelle contains a set of unique proteins .
In membranous organelles, these proteins are either incorporated into their membranes or sequestered within their lumens. For example, the enzymes of lysosomes are separated by a specific enzyme resistant membrane from the cytoplasmic matrix because their hydrolytic activity would be detrimental to the cell .
In Non membranous organelles, the unique proteins usually self-assemble into polymers that form the structural elements of the cytoskeleton .

Membrane bounded organelles
Endoplasmic reticulum (ER)

The endoplasmic reticulum (ER) is a network of membrane- enclosed tubules and sacs (cisternae) that extends from the nuclear membrane throughout the cytoplasm. The entire ER is enclosed by a continuous membrane and is the largest organelle of most **eukaryotic cells**. Its membrane may account for about half of all cell membrane and is enclosed a space (**the cisternal space**) (**or lumen**) from the cytosol.

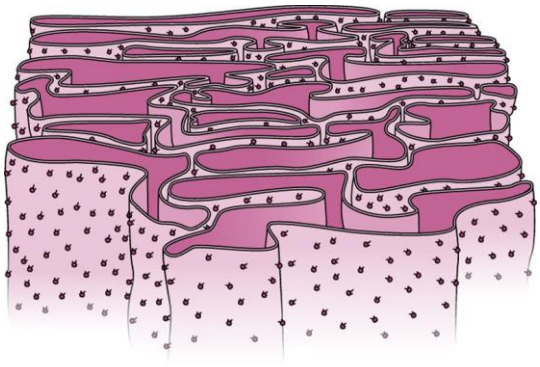


There are **2** types of ER that perform different functions within the cell:

1. **The rough ER**: which is covered by **ribosomes** on its outer surface giving it a rough appearance (hence its name). **functions** in **protein processing**.
2. **The smooth ER**: is **not** associated with ribosomes and involved in **lipid metabolism**.

Rough endoplasmic reticulum (RER):

Is found in all cells **except** erythrocytes and is especially abundant in glandular cells such as salivary gland cells.



Function of RER:

1. has a role in the synthesis of protein to be exported outside the cell.
2. modification of newly formed polypeptides.
3. assembly and folding of multichain protein.
4. initial glycosylation of the glycoprotein which means addition of glucose to the protein.

Clinical notes:

Dysfunction of the rough endoplasmic reticulum (ER) can contribute to various medical conditions, particularly those involving protein folding lead to protein misfolding disorders like Alzheimer's disease and Parkinson's disease.

Smooth endoplasmic reticulum (SER):

SER is found in a variety of cell types (both animal and plant), and it serves different functions in each.

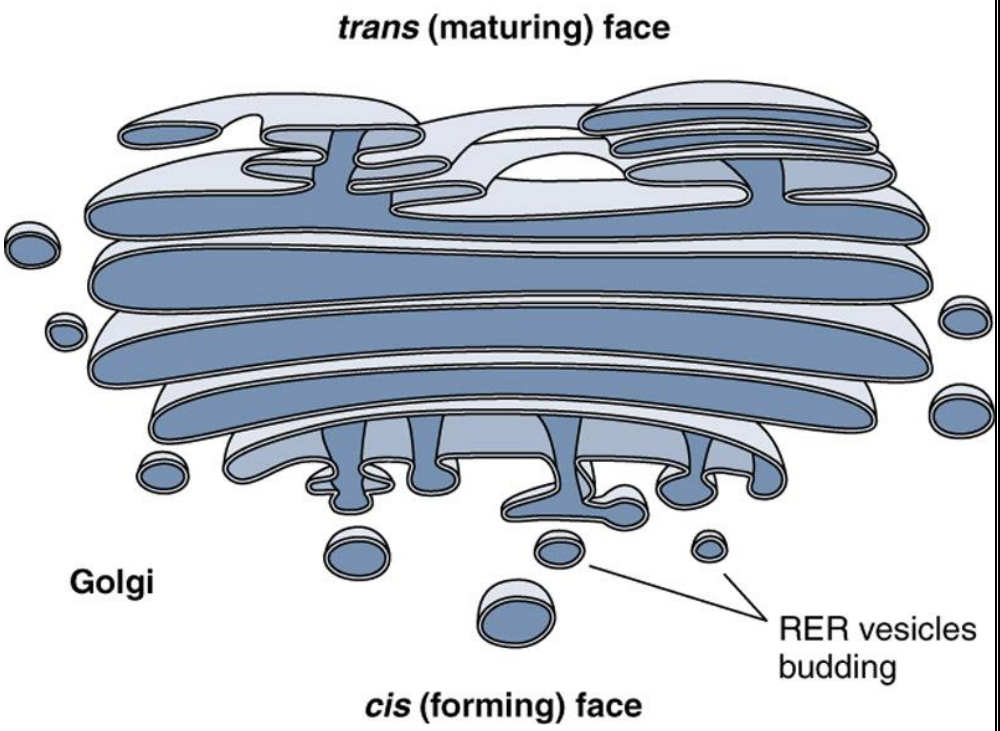
Function of SER:

1. It is abundant in the liver and intestinal epithelium and seems to be involved in detoxification of certain substances like alcohol and toxins.
2. Glycogen breaks down in the liver cells.
3. lipid and cholesterol metabolism.
4. biosynthesis of steroid hormones (adrenal gland).
5. participates in the contraction process in muscle cells, here SER is called **sarcoplasmic reticulum**.

Clinical notes:

Jaundice denotes a yellowish discoloration of the skin and is caused by accumulation of bilirubin and other pigmented compounds in extracellular fluid, which are normally metabolized by SER enzymes in cells of the liver and excreted as bile. A frequent cause of jaundice in newborn infants (physiological jaundice) is an underdeveloped state of SER in liver cells, with failure of bilirubin to be converted to a form that can be readily excreted.

Golgi apparatus



Golgi apparatus (Golgi complex) is an organelle found in typical **eukaryotic cells**. Its primary **function** is to **process and package macromolecules** synthesized by the cell, primarily proteins and lipids.

Structure:

The Golgi is composed of membrane- bound sacs known as **cisternae**. Between (5- 8) are usually present, however, as many as (60) have been observed. Surrounding the main cisternae are a no. of spherical vesicles which have budded off from the cisternae. The simplest model views the Golgi complex as consisting of **5** functional regions: **cis- Golgi network, cis- Golgi, medial Golgi, trans- Golgi, and trans- Golgi network.**

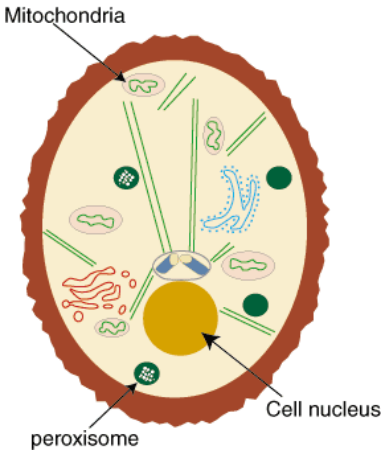
Protein &/or lipid vesicles from the endoplasmic reticulum fuse with the **cis- Golgi network** and subsequently progress through the stack to the **trans- Golgi network**, where they are packaged and sent to different locations in the cell.

Functions of Golgi apparatus:

1. participate in protein synthesis.
2. initial proteolysis (cutting of protein).
3. terminating glycolysis and glycosylation.
4. phosphorylation (addition of phosphate group).
5. sulfation (addition of sulfa group).
6. processing and sorting glycoprotein.
7. lipid metabolism.

Peroxisomes

Are organelles in eukaryotes that function to rid the cells of toxic substances. Peroxisomes are small membrane- enclosed organelles that contain enzymes involved in a variety of metabolic reactions.



Functions of peroxisomes:

1) Peroxisomes contain enzymes for oxidizing certain organic substances with the formation of hydrogen peroxide (H_2O_2)

$$RH2 + O2 \longrightarrow R + H2O2$$

Catalase, another enzyme in the peroxisome, in turn uses this H_2O_2 to oxidize other substrates like alcohol, by means of the peroxidation reaction:

$$H2O2 + RH2 \longrightarrow R + 2H2O$$

Thus, eliminating the poisonous hydrogen peroxide in this process. This reaction is important in liver and kidney cells where the peroxisomes detoxify various toxic substances that enter the blood. About 50% of the ingested ethanol is oxidized to acetaldehyde in this way. In addition, when excess H2O2 accumulates in the cell, catalase converts it to H_2O through this reaction:

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

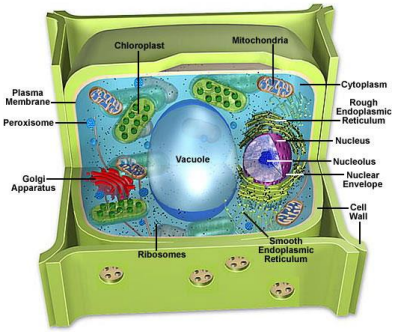
2) Peroxisomes are involved in lipid biosynthesis.
3) Peroxisomes play a role in the production of bile acids.

Clinical notes:

1. Many disorders arise from defective peroxisomal proteins, because this organelle is involved in several metabolic pathways.
2. Deficiency in peroxisomal enzymes causes the fatal Zellweger syndrome, with severe muscular impairment, liver and kidney lesions, and disorganization of the central and peripheral nervous systems. Electron microscopy reveals empty peroxisomes in liver and kidney cells of these patients.

Vacuoles

Vacuoles are membrane- bound compartments within some eukaryotic cells.



Functions of vacuoles:

1. isolating materials that might be harmful to the cell.
2. marinating internal hydrostatic pressure within the cell.
3. maintaining an acidic internal pH.
4. enabling the cell to change shape.

Vesicles

A vesicle is a relatively small and enclosed compartment. Vesicles store, transport or digest cellular products and waste products.

Many vesicles are made in the Golgi apparatus, but also in the endoplasmic reticulum, or are made from parts of the plasma membrane.