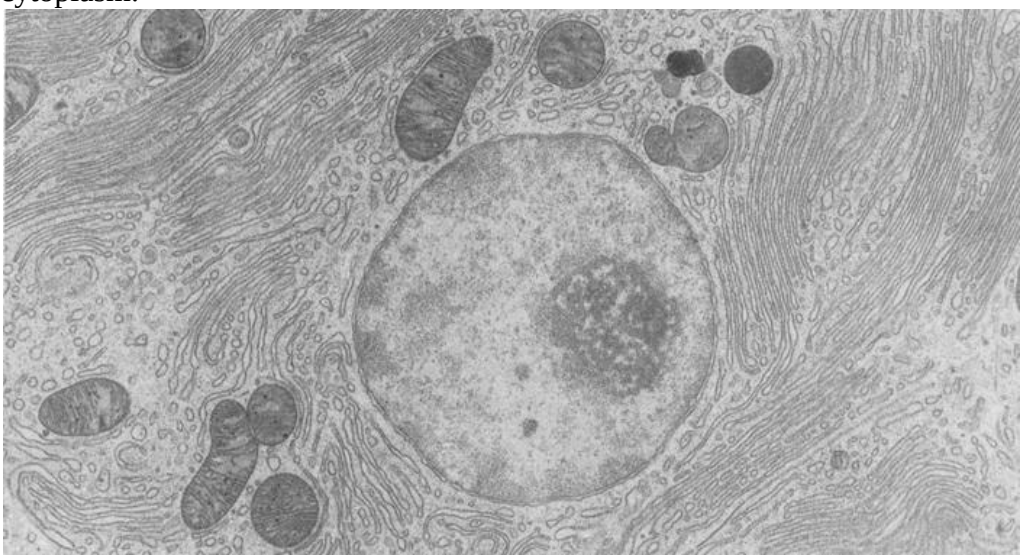
Cytoplasm

The cytoplasm is the part of the cell located outside the nucleus full the space between nuclear envelop and plasma membrane consists of

1. **Cytosol** is a larger fluid component.
2. **Organelles** ("little organs") are bathing metabolically active structures, which may be membranous (such as mitochondria) or non membranous protein complexes (such as ribosomes and proteasomes).
3. **Cytoskeleton** is protein components which determine the shape and motility of eukaryotic cells.
4. **Inclusions** are the minor cytoplasmic structures that are not usually surrounded by a plasma membrane. They consist of such diverse materials as crystals, pigment granules, lipids, glycogen, and other stored waste products.

Cytosol

- Cytosol is an aqueous gel called the **cytoplasmic matrix** or cell sap.
- Cytosol is colorless watery fluid or gelatinous liquid (semi fluid) that fills the inside of a cell and surrounds the organelles.
- The matrix consists of a variety of solutes, including inorganic ions (Na, K, and Ca2) and organic molecules such as intermediate metabolites, carbohydrates, lipids, proteins, and RNAs.
- Cytosol also contains hundreds of enzymes, all the machinery converging on the ribosomes for protein synthesis.
- Oxygen, CO2, electrolytic ions, low-molecular-weight substrates, metabolites, and waste products all diffuse through cytosol, either freely or bound to proteins, entering or leaving organelles where they are used or produced.
- **L.M.** of cytosol: It appears as homogenous or finely granular ground substance, commonly acidophilic in reaction but may be basophilic or neutrophilic.
- **E.M.** of cytosol: Appear as **amorphous** substance with variety of **electron densities**.
- Function of cytosol: Provides a suitable medium for reactions occurring in the cytoplasm.



Electron microscope cell image

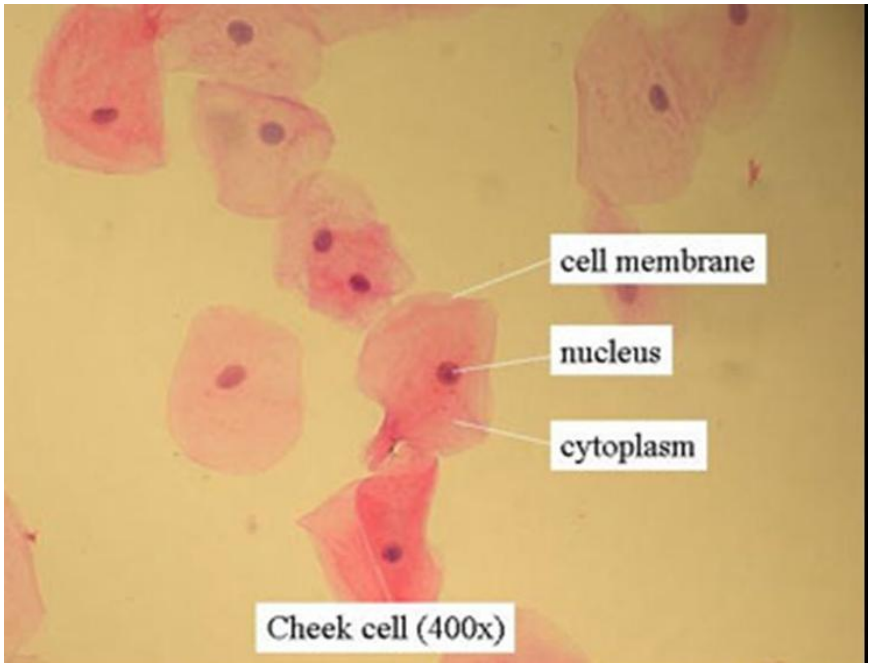


Figure shows cells image under light microscope

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 (naked organelles).

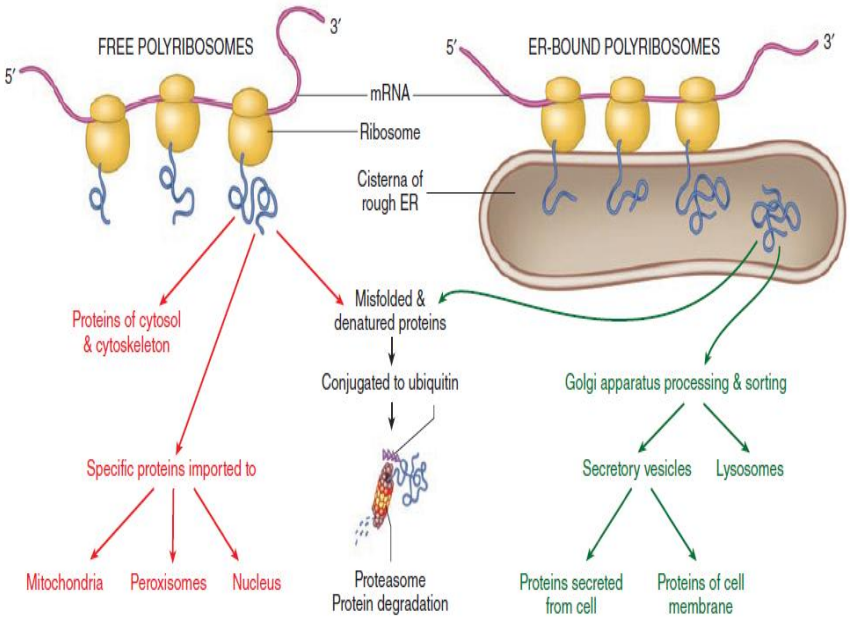
- ✓ The membranes of membranous organelles form vesicular, tubular, and other structural patterns within the cytoplasm that may be convoluted (as in endoplasmic reticulum) or plicated (as in the inner mitochondrial membrane).
- ✓ In addition, each type of organelle contains a set of **unique** proteins**.**
- ✓ **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 organelles.

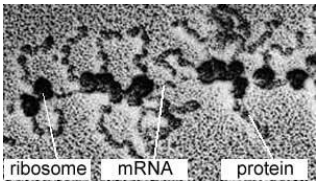
Ribosomes

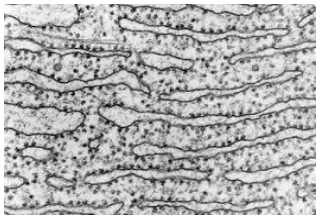
- ✓ Ribosomes are membrane naked organelles present in all cells types(prokaryotes and eukaryotes)
- ✓ Ribosomes are small electron-dense particles, about 20 × 30 nm in size. Composed of four segments of rRNA and approximately 80 different proteins.
- ✓ All ribosomes have two subunits of different sizes and act to catalyze the process of protein translation (Protein synthesis), so that is more abundant in protein secreting cells.
- ✓ In eukaryotic cells, the rRNA molecules of both subunits are synthesized within the nucleus. Their numerous proteins are synthesized in the cytoplasm but then enter the nucleus and associate with rRNAs. The assembled large and

small subunits then leave the nucleus and enter the cytoplasm to participate in protein synthesis.

- ✓ Ribosomes are often **attached** to the endoplasmic reticulum; but they also may occur **free** within the cytoplasm.
- ✓ Multiple ribosomes on the same mRNA make up a polyribosome **(polysome)** and an abundance of these produces basophilic cytoplasm after H&E staining.
- ✓ The location of the ribosome in a cell determines what kind of protein it makes. If the ribosomes are floating freely through the cell, it will make proteins that will be utilized within the cell itself. But when the ribosomes are attached to endoplasmic reticulum, proteins made on the rough endoplasmic reticulum are used for usage inside the cell or outside the cell.







Endoplasmic reticulum (ER)

- Membrane bounded organelles.
- The ER is a convoluted network of membrane enclosing continuous spaces called cisternae and extending from the nucleus to the plasma membrane.
- There are two types of ER according to the present of ribosome, **Rough ER** and **Smooth ER.**
- The functions of ER are

  1. Synthesis: Provides a place for chemical reactions

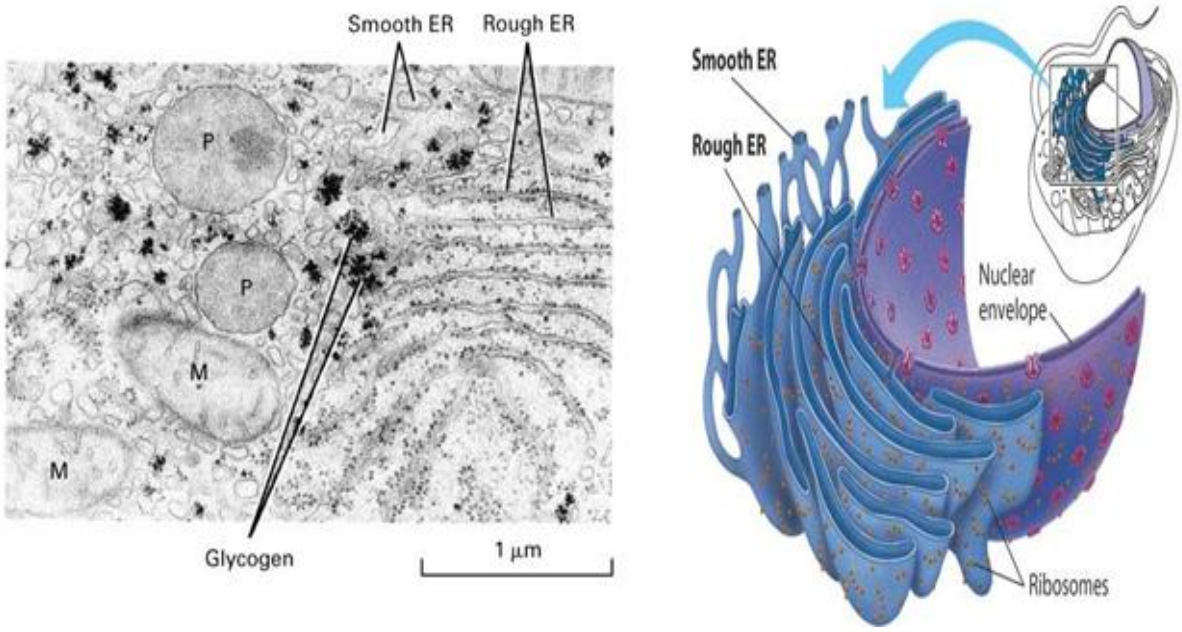
  a. Smooth ER is the site of lipid synthesis and carbohydrate metabolism

  b. Rough ER synthesizes proteins for secretion, incorporation into the plasma, membrane, and as enzymes within lysosomes

  2. **Transport:** Moves molecules through cisternal space from one part of the cell to another, sequestered away from the cytoplasm

  3. **Storage:** Stores newly synthesized molecules

  4. **Detoxification:** Smooth ER detoxifies both drugs and alcohol



Transmission EM of RER&SER

Rough ER (RER)

The RER consists of saclike as well as parallel stacks of flattened cisternae, each limited by membranes that are continuous with the outer membrane of the nuclear envelope. The presence of polyribosomes on the cytosolic surface of the RER confers basophilic staining properties on this organelle when viewed with the light microscope. Is found in all cells except erythrocytes and is especially abundant in cells specialized for protein secretion, such as pancreatic acinar cells (making digestive enzymes), fibroblasts (collagen), and plasma cells (immunoglobulins).

Functions of RER:

1. Has role in the synthesis of protein to be exported outside the cell.
2. Modification of newly formed polypeptides.
3. Assembly of multichain protein.
4. Initial glycosylation of the glycoprotein which means addition of glucose to the protein.

These activities are mediated by resident enzymes of the RER and by protein complexes that act as **molecular chaperones** guiding the folding of nascent proteins, inhibiting aggregation, and generally monitoring protein quality within the ER.

✓ RER has a highly regulated system to prevent nonfunctional proteins being forwarded to the pathway for secretion or to other organelles. New proteins that cannot be folded or assembled properly by molecular chaperones undergo **ER-associated degradation (ERAD)**, in which unsalvageable proteins are translocated back into the cytosol, conjugated to ubiquitin, and then degraded by proteasomes.

MEDICAL APPLICATION

Quality control during protein production in the RER and properly functioning ERAD to dispose of defective proteins are extremely important and several inherited diseases result from malfunctions in this system. **For example**, in some

forms of osteogenesis imperfect bone cells synthesize and secrete defective procollagen molecules which cannot assemble properly and produce very weak bone tissue.

Smooth ER (SER)

- ✓ Regions of ER that lack bound polyribosomes make up the smooth endoplasmic reticulum (SER), which is continuous with RER but frequently less abundant. Lacking polyribosomes, SER is not basophilic and is best seen with the TEM.
- ✓ SER cisternae are often more tubular and more likely to appear as interconnected channels of various shapes and sizes than as stacks of flattened cisternae.
- ✓ SER contains some enzymes also found in RER, but is specialized for other distinct functions, including glycogen and lipid metabolism, detoxification reactions, and temporary Ca2+ sequestration.

Functions of SER:

1. **A major role of enzymes in the SER is *phospholipid synthesis***, including the various phospholipids that are major constituents of cellular membranes.
2. In cells that secrete steroid hormones (eg, cells of the adrenal cortex), SER occupies a large portion of the cytoplasm and contains enzymes required for ***steroid synthesis.***
3. SER is also abundant in many liver cells, where it contains enzymes responsible for glycogen metabolism, for processing endogenous molecules such as the components of bile, and for the oxidation, conjugation, and methylation reactions that neutralize potentially toxic exogenous molecules such as alcohol, and other drugs. Important for such ***detoxification reactions*** are enzymes of the cytochrome P450 family.
4. Another function of the SER is to ***sequester and release Ca2+*** in a controlled manner, which is part of the rapid response of cells to various stimuli. This function is very well developed in muscle cells, where the SER has an important role in the contraction process and assumes a specialized form called the sarcoplasmic reticulum

MEDICAL APPLICATION

Jaundice denotes a yellowish discoloration of the skin and is caused by accumulation in extracellular fluid of bilirubin and other pigmented compounds, 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.