KİM 425
KİMYACILAR İÇİN HÜCREBİLİM

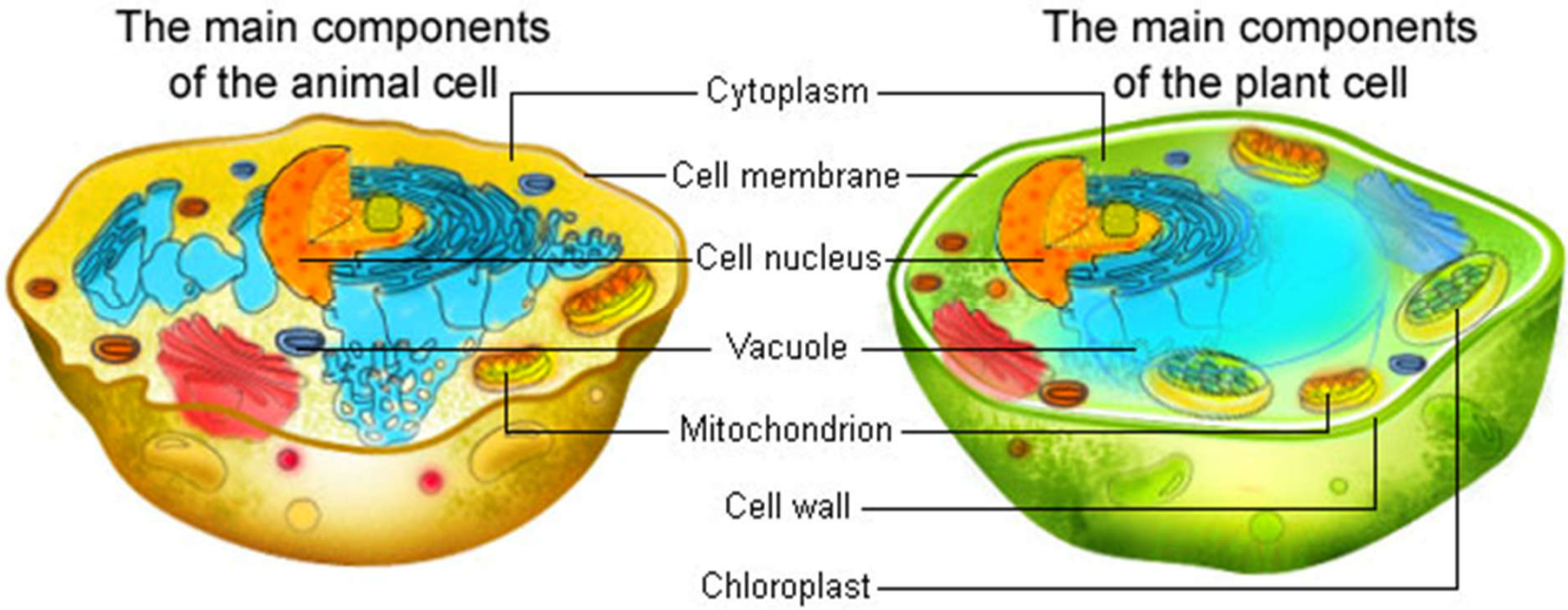
DERS IV-IX

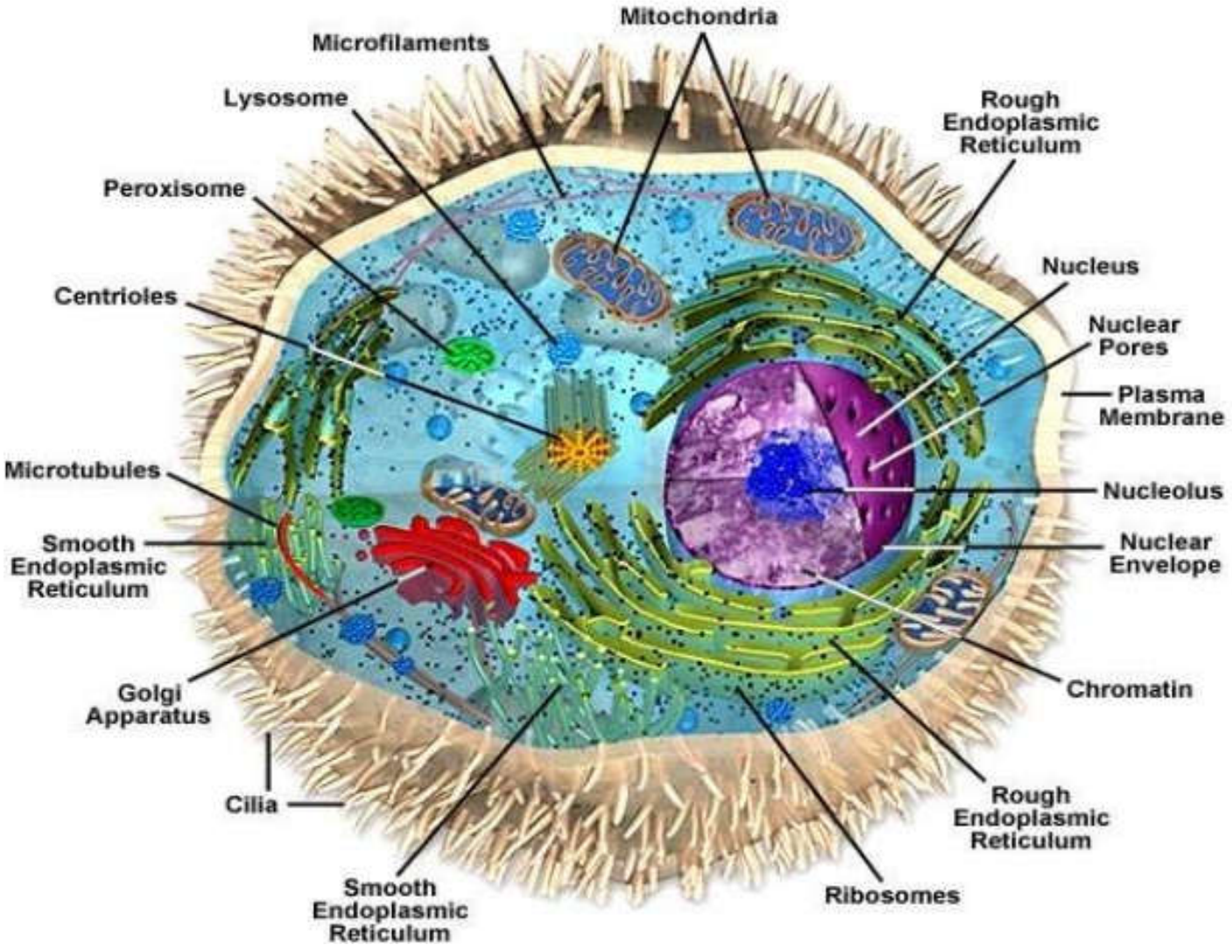
Hücrelerde Organeller ve Biyokimyasal Rolleri Ökaryotik hücrelerde belirli işlevleri olan ve belirli bir zar ile çevrili organeller bulunur. Bu organeller çok çeşitlidir. Başlıcaları;

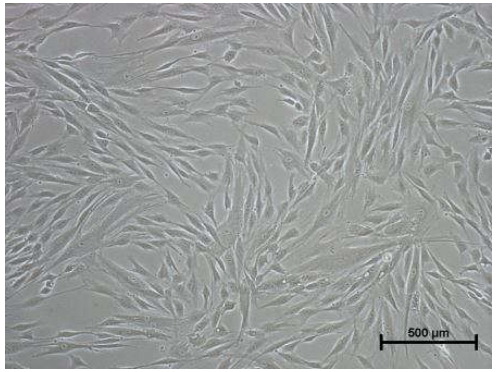
- ☐ Nukleus – Çekirdek
- ☐ Endoplasmik Retikulum
- ☐ Golgi Cisimciği
- ☐ Ribozom
- ☐ Mitokondri
- ☐ Kloroplast
- ☐ Lizozom
- ☐ Peroksizom

The Cell

- The smallest unit that can perform all life processes




Mitochondria
Microfilaments
Lysosome
Rough Endoplasmic Reticulum
Peroxisome
Nucleus
Centrioles
Nuclear Pores
Plasma Membrane
Microtubules
Nucleolus
Smooth Endoplasmic Reticulum
Nuclear Envelope
Chromatin
Golgi Apparatus
Cilia
Rough Endoplasmic Reticulum
Smooth Endoplasmic Reticulum
Ribosomes



Mesencymal stem cells

Epitelial cells

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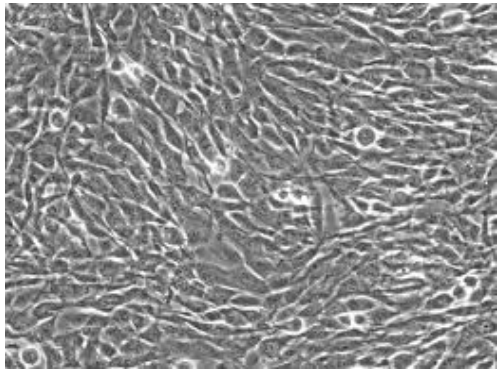
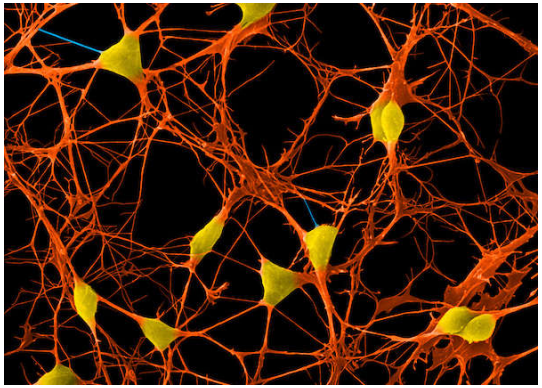


Dermal fibroblast cells



Cortical nerve cells

Organization of cells

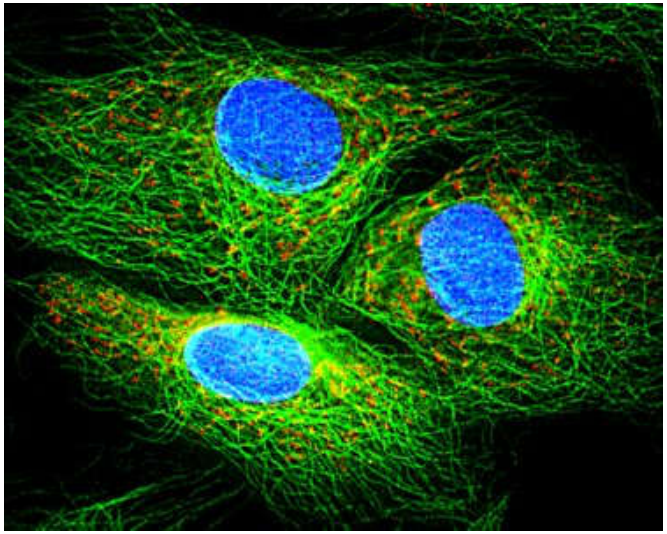
- Eukaryotic cells contain well defined cellular organelles such as:
  - Nucleus
  - Mitochondria
  - Endoplasmic reticulum
  - Golgi apparatus
  - Peroxisomes
  - Lysosomes

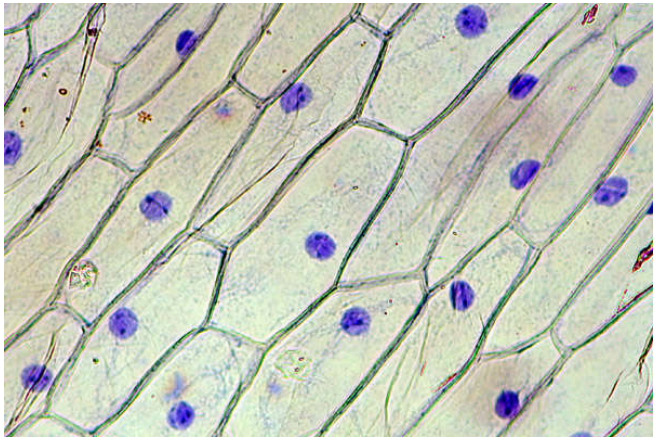
NUCLEUS

The nucleus is the largest cellular organelle in animals. In mammalian cells, the average diameter of the nucleus is approximately 6 micrometers (μm), which occupies about 10% of the total cell volume. The viscous liquid within it is called nucleoplasm, and is similar in composition to the cytosol found outside the nucleus. It appears as a dense, roughly spherical organelle.

"The Control Center"

- Eukaryotic cells contain a nucleus.
- It has got two membranes- nuclear envelope.
- Outer membrane is continuous with the membrane of endoplasmic reticulum.
- Nuclear envelope has numerous pores. That permit controlled movement of particles and molecules between the nuclear matrix and cytoplasm.





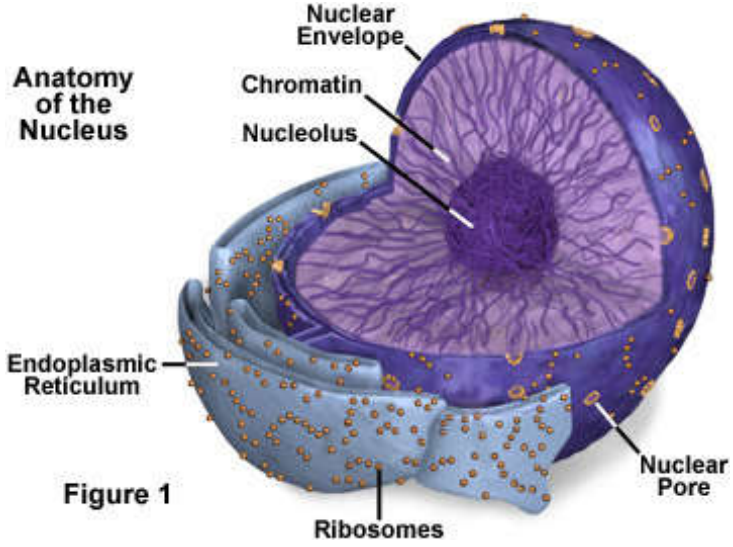
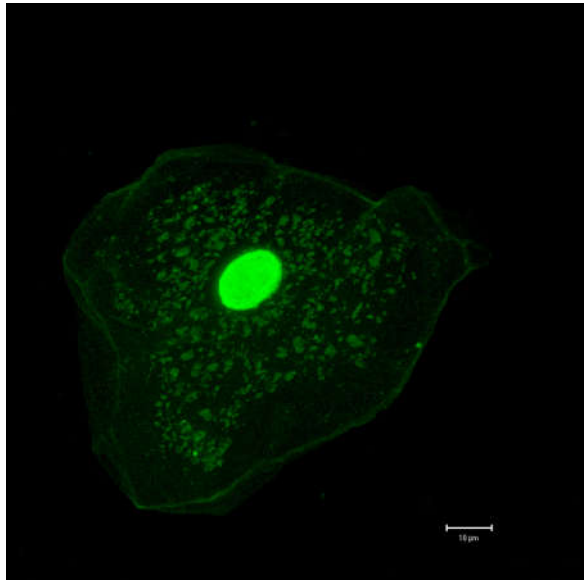
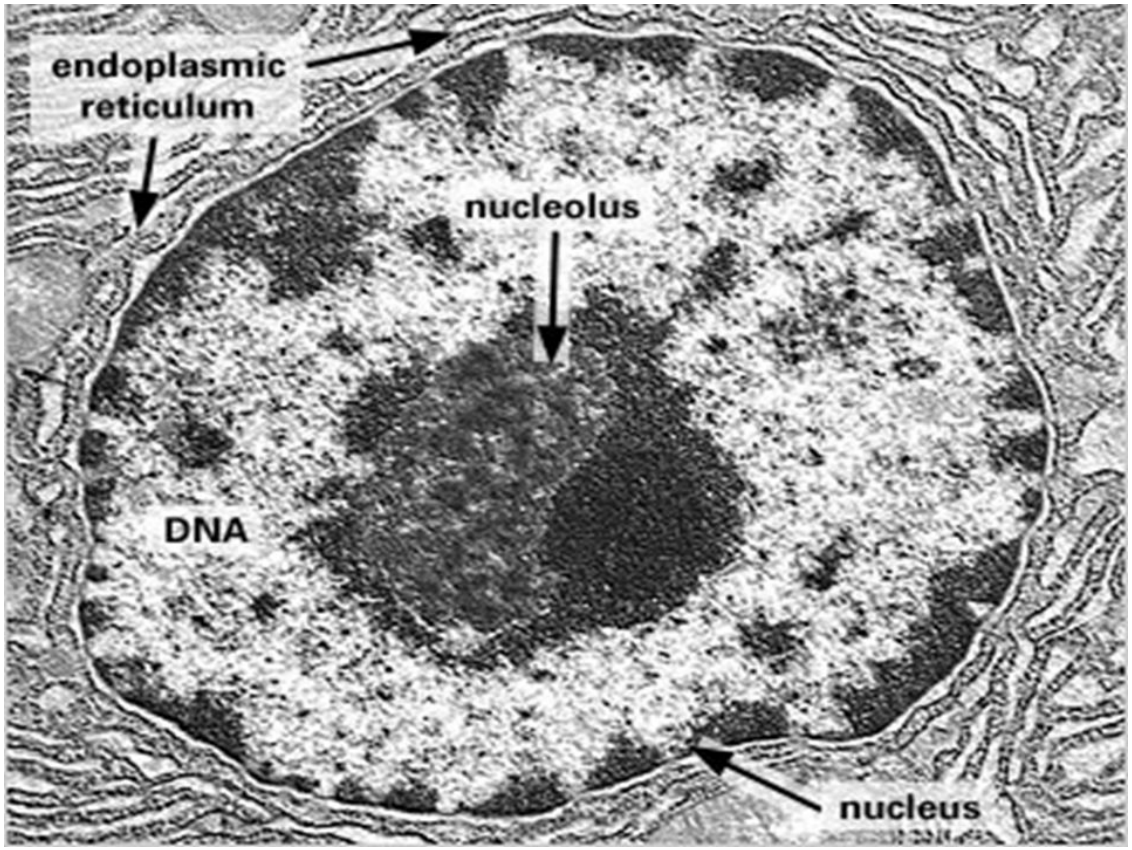

Anatomy of the Nucleus
Nuclear Envelope
Chromatin
Nucleolus
Endoplasmic Reticulum
Nuclear Pore
Ribosomes

Figure 1



- Nucleus has got a major sub compartment- nucleolus.
- Deoxyribonucleic acid (DNA) is located in the nucleus. It is the repository of genetic information.
- Present as DNA- protein complex –Chromatin, which is organized into chromosomes.
- A typical human cell contains 46 chromosomes.
- To pack it effectively it requires interaction with a large number of proteins. These are called histones.
- They order the DNA into basic structural unit called Nucleosomes. Nucleosomes are further arranged into more complex structures called chromosomes


endoplasmic
reticulum
nucleolus
DNA
nucleus

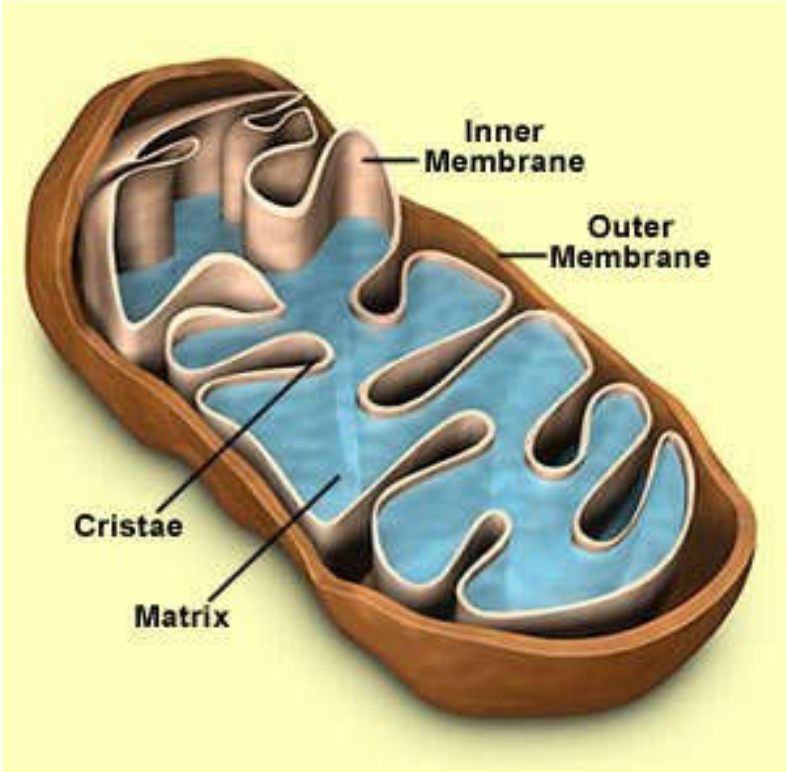
Biochemistry point of view

- Nucleus contains the biochemical processes involved in the Replication of DNA before mitosis.
- Involved in the DNA repair.
- Transcription of DNA – RNA synthesis.
- Translation of DNA- Protein synthesis.
- NUCLEOLUS- involved in the processing of rRNA and ribosomal units
- After being produced in the nucleolus, ribosomes are exported to the cytoplasm where they translate mRNA.

MITOCHONDRIA

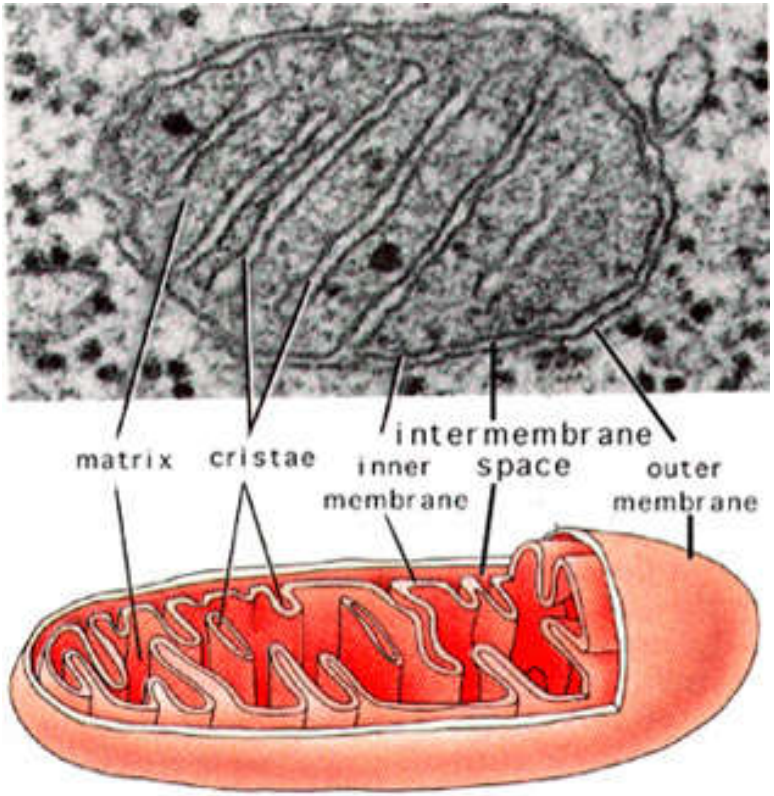
- In electron micrographs of cells, mitochondria appears as – rods, spheres or filamentous bodies.
- Size: 0.5µm -1µm in diameter

  up to 7µm in length.



FEATURES

- Mitochondria has got an inner membrane and an outer membrane. The space between these two is called intermembranous space.
- Inner membrane convolutes into cristae and this increases its surface area.
- Both the membranes have different appearance and biochemical functions:



Outer membrane:

It is permeable to most ions and molecules which can move from the cytosol to intermembranous space.

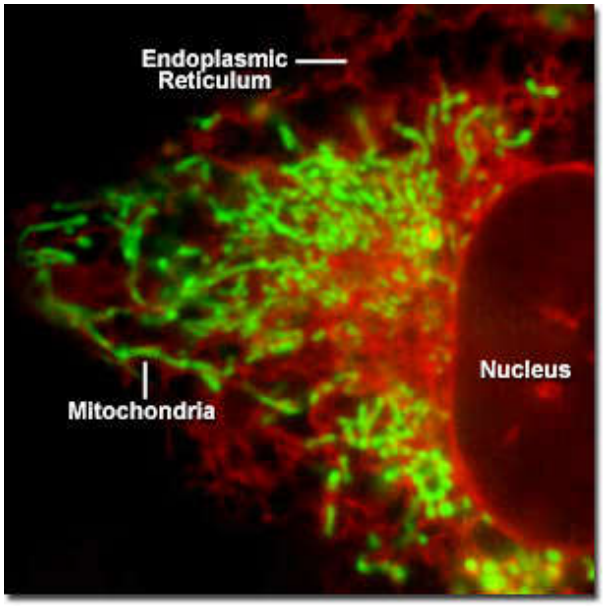
Matrix:

- It is enclosed by the inner mitochondrial membrane.
- Contains enzymes of citric acid cycle.

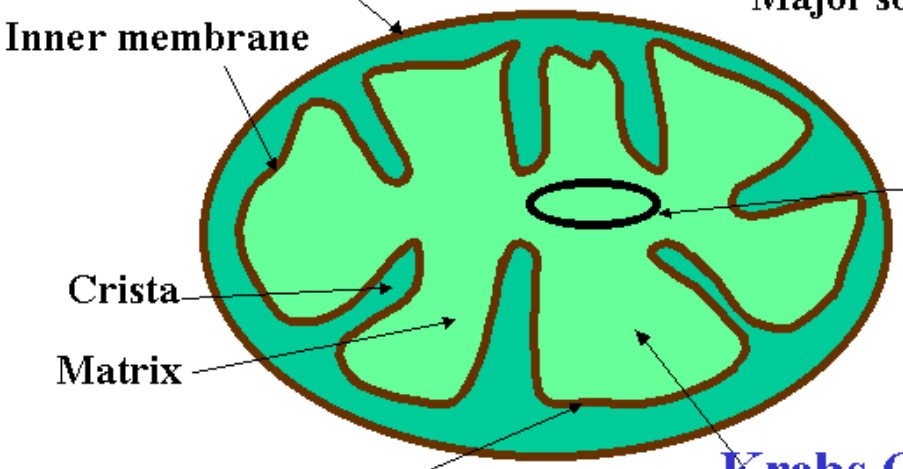
Biochemistry point of view

Inner membrane:

- It surrounds the matrix.
- It contains components of electron transport system.
- It is impermeable to most ions including H, Na, ATP, GTP, CTP etc and to large molecules.
- For the transport special carriers are present e.g. adenine nucleotide carrier(ATP –ADP transport).
- Complex II i.e. Succinate dehydrogenase .
- Complex V i.e. ATP synthase complex.



Mitochondria



Function:
Synthesis of ATP
Major source of energy

Mitochondrial DNA

Krebs Cycle

Sucrose + 6 O_2 + 38 ADP+ 38 Pi

↓

6 CO_2 + 6 H_2O + 38 ATP

- Enzymes of β-oxidation of fatty acids.
- Enzymes of amino acids oxidation.
- Some enzymes of urea and heme synthesis.
- NAD
- FAD
- ADP,Pi.
- Mitochondrial DNA.
- Mitochondrial cytochrome P450 system-

a. Hydroxylation of cholesterol to steroid hormones (placenta, adrenal cortex, ovaries and testes)
b. Bile acid synthesis (liver)
c. Vitamin D formation(kidney).

- Mitochondria plays a key role in aging-

  Cytochrome c component of ETC plays a main role in cell death and apoptosis.
- Mitochondria have a role in its own replication- they contain copies of circular DNA called mitochondrial DNA, this DNA have information for 13 mitochondrial proteins and some RNAs. This is DNA inherited from mothers.

- Most mitochondrial proteins are derived from genes in nuclear DNA.
- Mutation rate in mt DNA is 10 times more.

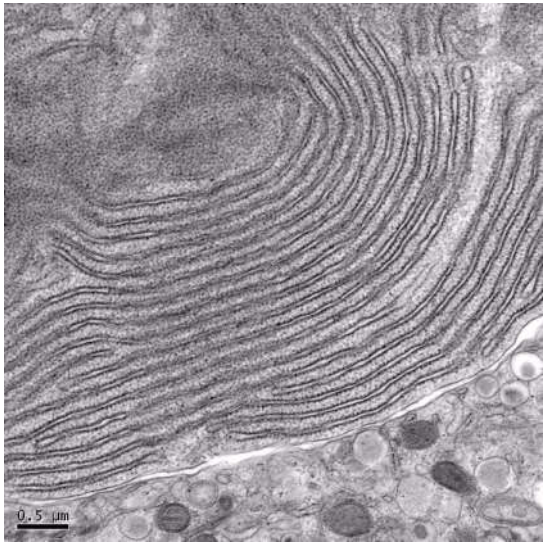
- Mitochondrial Diseases:

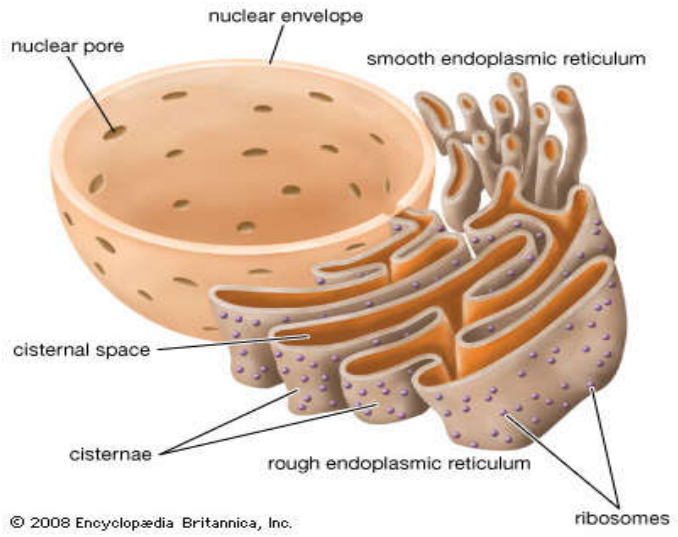
i. Fatal infantile mitochondrial myopathy and renal dysfunction
ii. MELAS(mitochondrial encephalopathy, lactic acidosis and stroke).

ENDOPLASMIC RETICULUM

- Cytoplasm of eukaryotic cells contain a network of interconnecting membranes. This extensive structure is called endoplasmic reticulum.
- It consists of membranes with smooth appearance in some areas and rough appearance in some areas-

  Smooth endoplasmic reticulum and rough endoplasmic reticulum.





Biochemistry point of view

Rough Endoplasmic Reticulum

- These membranes enclose a lumen.
- In this lumen newly synthesized proteins are modified.
- Rough appearance is due to the presence of ribosomes attached on its cytosolic side(outer side).
- These ribosomes are involved in the biosynthesis of proteins.

- These proteins are either incorporated into the membranes or into the organelles.
- Special proteins are present that are called CHAPERONES. These proteins play a role in proper folding of proteins.
- Protein glycosylation also occurs in ER i.e. the carbohydrates are attached to the newly synthesized proteins.

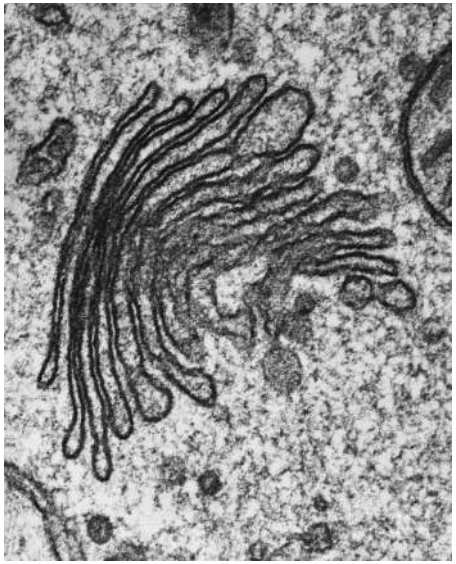
Smooth Endoplasmic Reticulum

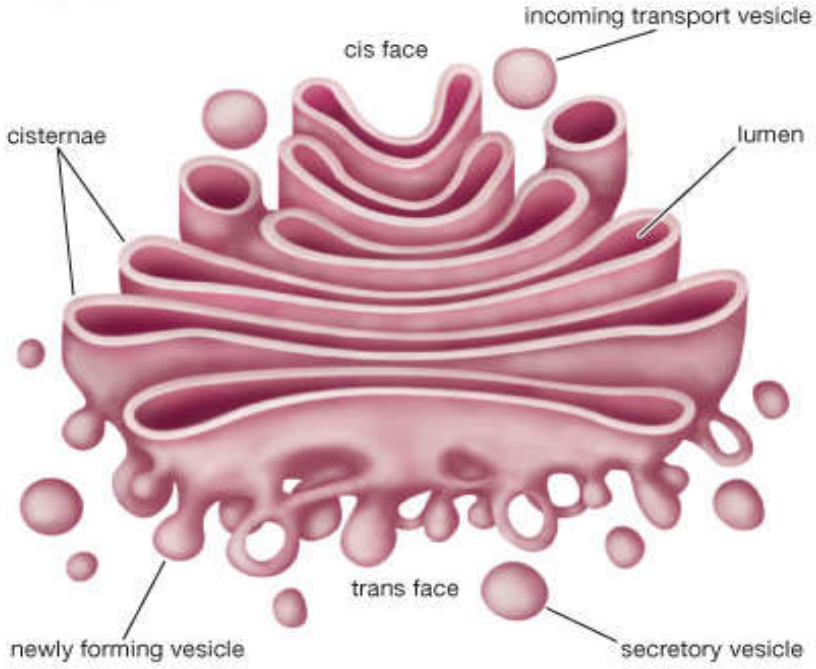
- Smooth endoplasmic reticulum is involved in lipid synthesis.
- Cholesterol synthesis
- Steroid hormones synthesis.
- Detoxification of endogenous and exogenous substances.
- The enzyme system involved in detoxification is called Microsomal Cytochrome P450 monooxygenase system(xenobiotic metabolism).

- ER along with Golgi apparatus is involved in the synthesis of other organelles – lysosomes & Peroxisomes.
- Elongation of fatty acids e.g. Palmitic acid 16 C- Stearic acid 18 C.
- Desaturation of fatty acids.
- Omega oxidation of fatty acids.

GOLGI APPARATUS

- Golgi complex is a network of flattened smooth membranous sacs- cisternae and vesicles.
- These are responsible for the secretion of proteins from the cells(hormones, plasma proteins, and digestive enzymes).
- It works in combination with ER.



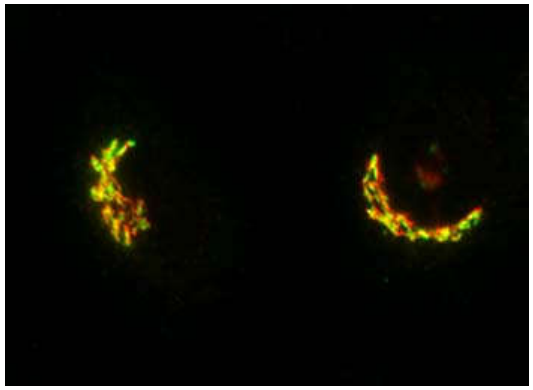


Biochemistry point of view

- Enzymes in golgi complex transfer carbohydrate units to proteins to form of glycoporoteins, this determines the ultimate destination of proteins.
- Golgi is the major site for the synthesis of new membrane, lysosomes and peroxisomes.
- It plays two major roles in the membrane synthesis:

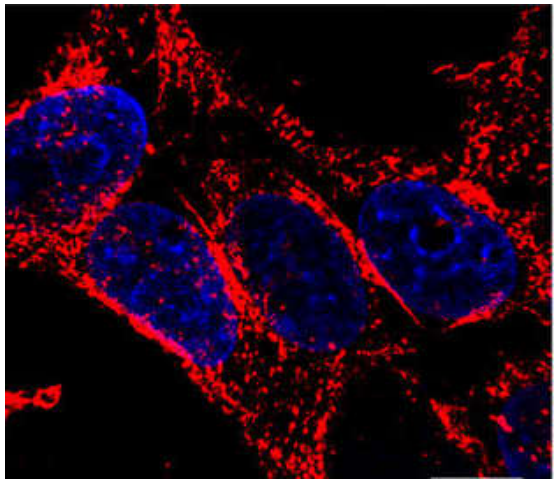
i. It is involved in the processing of oligosaccharide chains of the membranes (all parts of the GA participates).

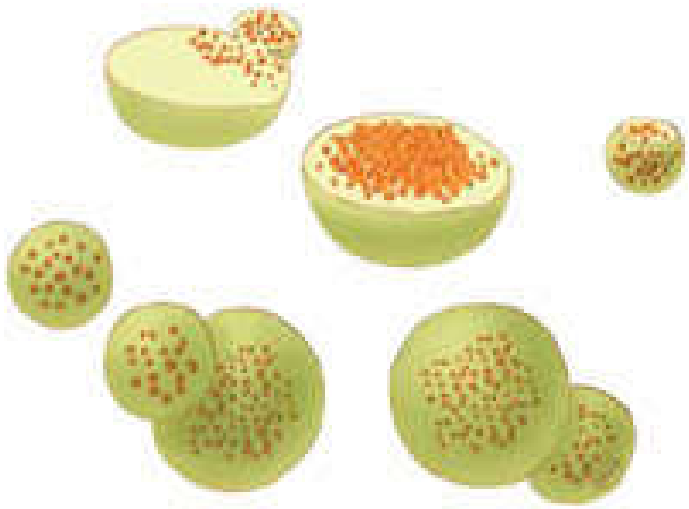
ii. It is involved in the sorting of various proteins prior to their delivery(Trans Golgi network).



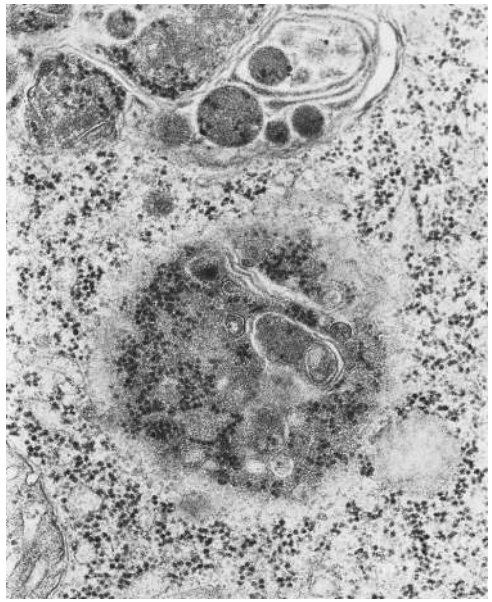
LYSOSOMES

- These are responsible for the intracellular digestion of both intra and extracellular substances.
- They have a single limiting membrane.
- They have an acidic pH- 5
- They have a group of enzymes called Hydrolases.

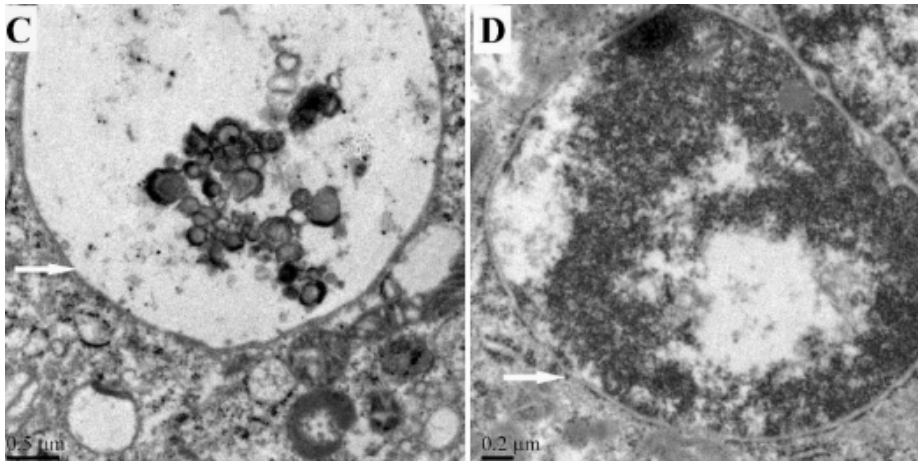




Biochemistry point of view



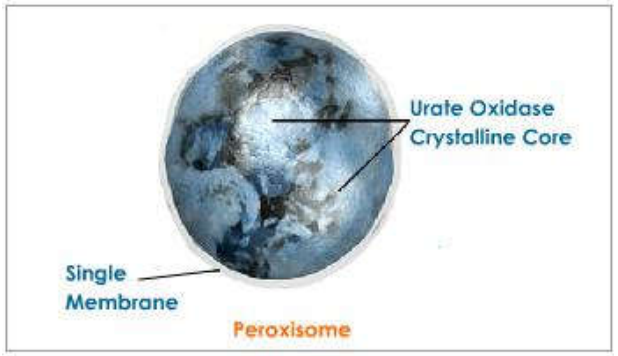
- The enzyme content varies in different tissues according to the requirement of tissues or the metabolic activity of the tissue.
- Lysosomal membrane is impermeable and specific translocators are required.
- Vesicles containing external material fuses with lysosomes, form primary vesicles and then secondary vesicles or digestive vacoules.
- Lysosomes are also involved in autophagy.

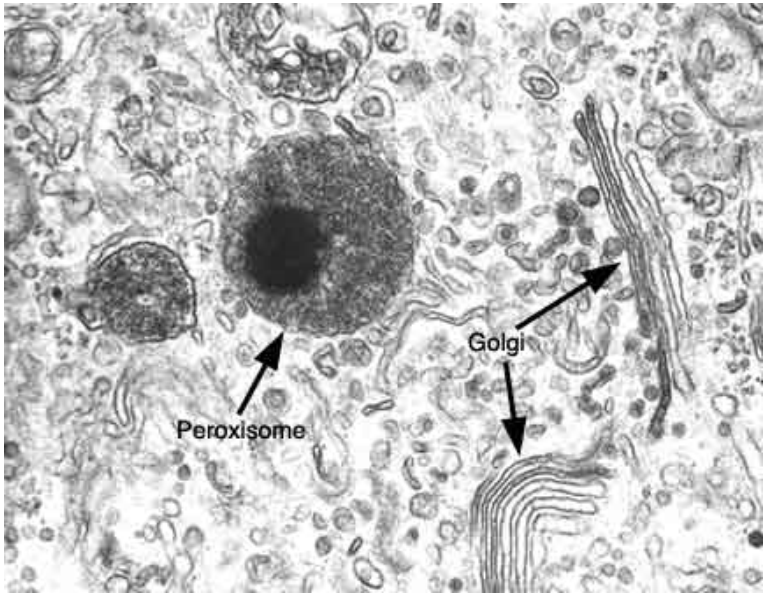


- In some genetic disease individual lysosomal enzymes are missing and this lead to the accumulation of that particular substance.
- Such lysosomes gets enlarged and they interfere the normal function of the cell.
- Such diseases are called lysosomal storage diseases
- Most impt is I-cell disease.

PEROXISOMES

- Called Peroxisomes because of their ability to produce or utilize H_2O_2.
- They are small, oval or spherical in shape.
- They have a fine network of tubules in their matrix.
- About 50 enzymes have been identified.
- The number of enzymes fluctuates according to the function of the cells.





Biochemistry point of view

- Xenobiotics leads to the proliferation of Peroxisomes in the liver.
- Have an important role in the breakdown of lipids, particularly long chain fatty acids.
- Synthesis of glycerolipids.
- Synthesis of glycerol ether lipids.
- Synthesis of isoprenoids.
- Synthesis of bile.
- Oxidation of D- amino acids.
- Oxidation of Uric acid to allantoin (animals)
- Oxidation of Hydroxy acids which leads to the formation of H_2O_2.
- Contain catalase enzyme, which causes the breakdown of H_2O_2 .