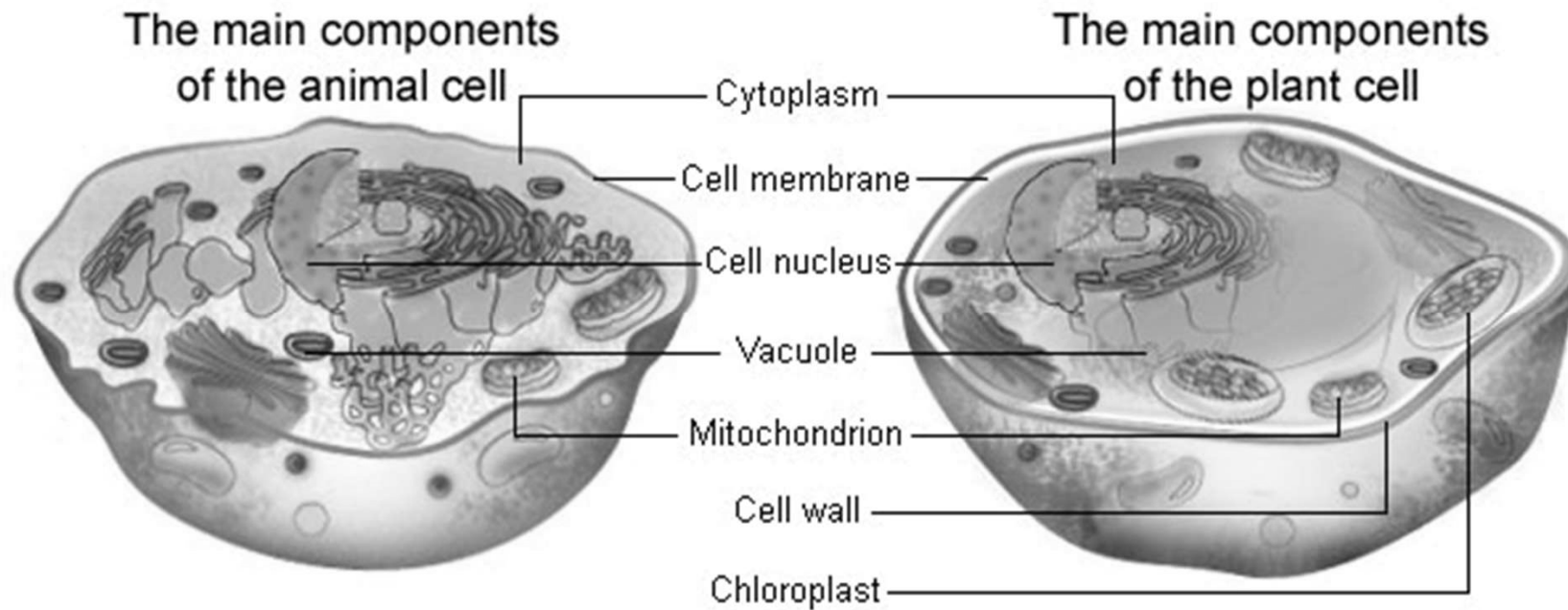
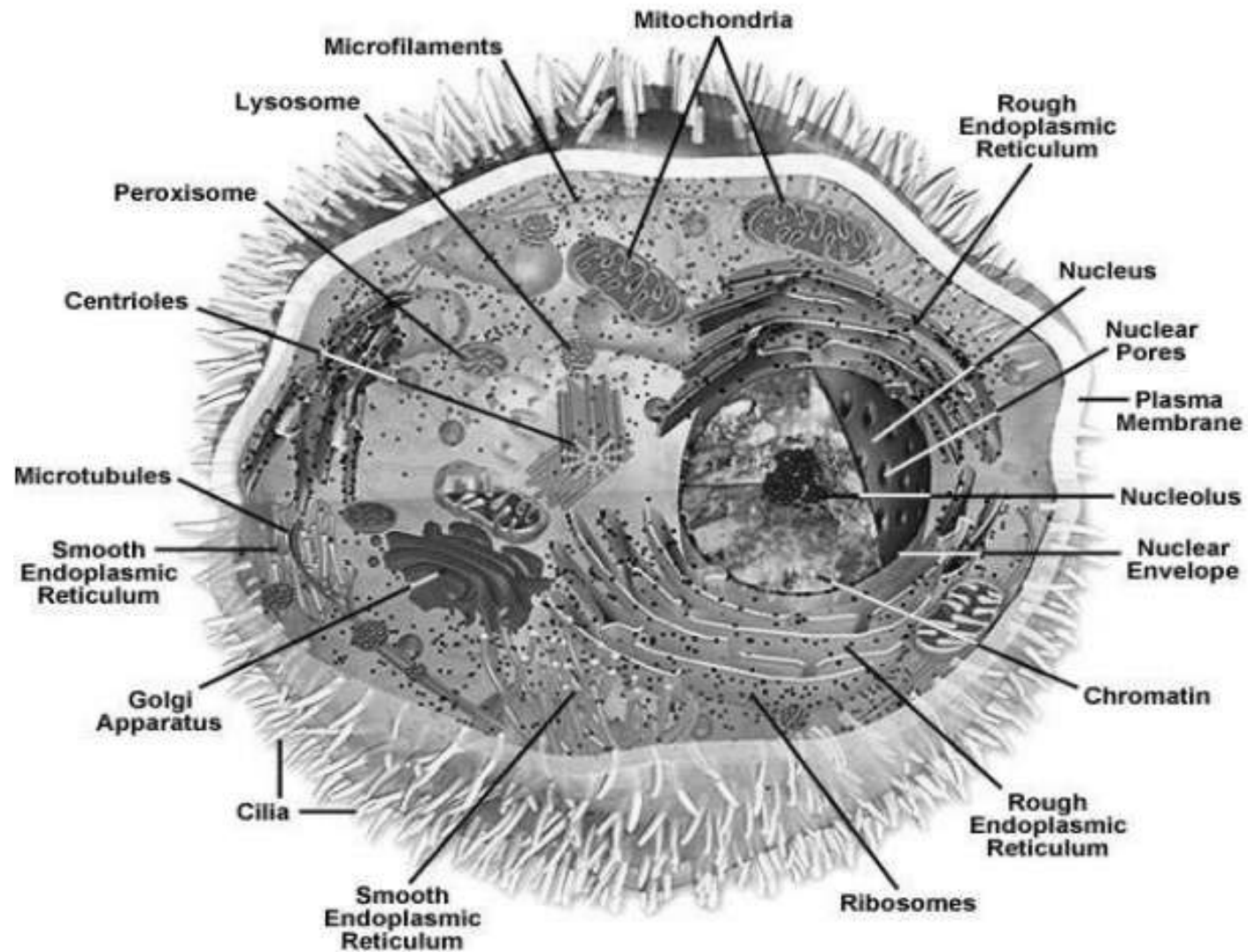


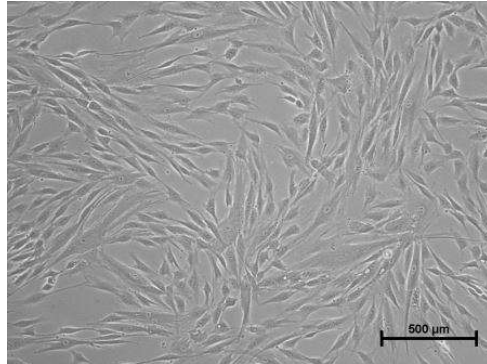
CHM 425
CYTOLOGY FOR CHEMIST
PART II

The Cell

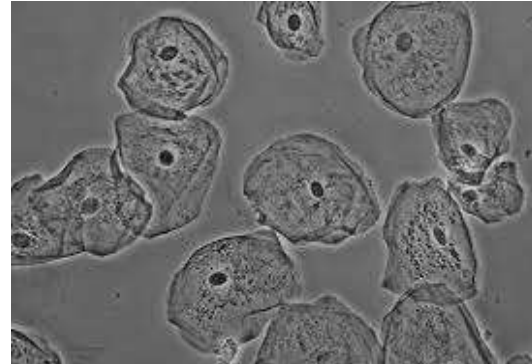
- The smallest unit that can perform all life processes



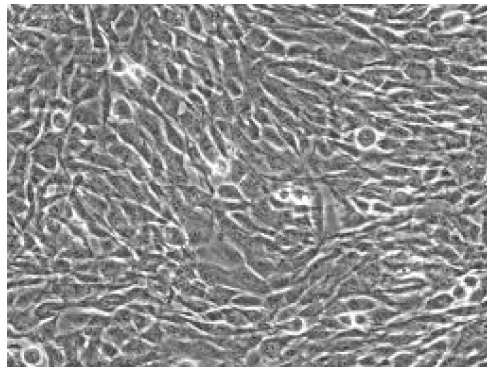




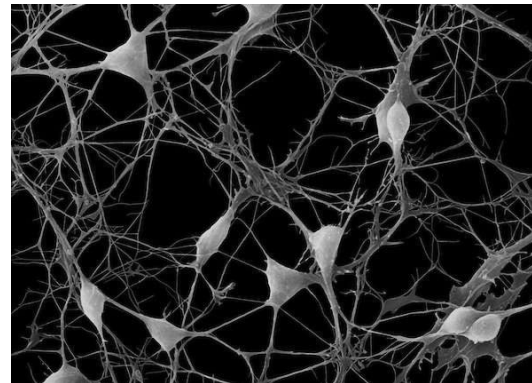
Mesenchymal stem cells



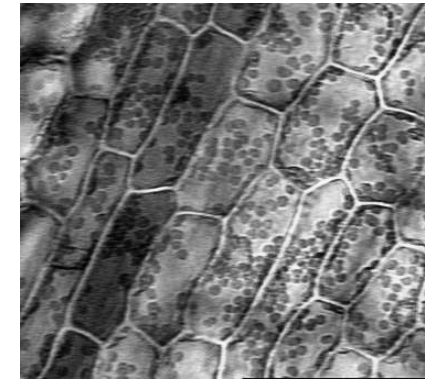
Epithelial cells



Dermal fibroblast cells



Cortical nerve cells



????

Organization of cells

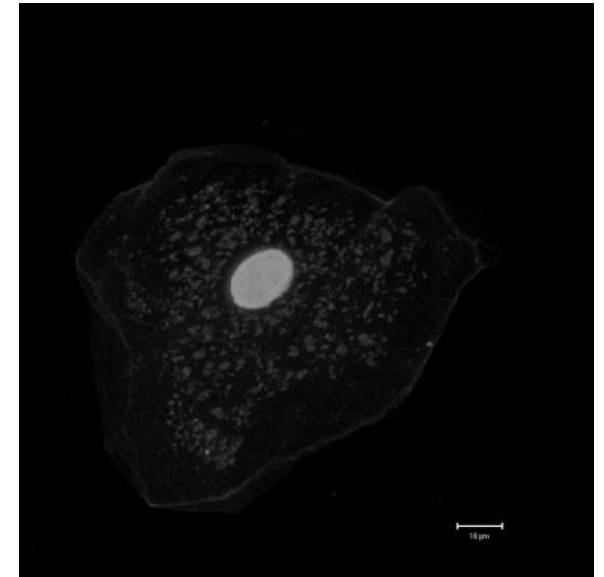
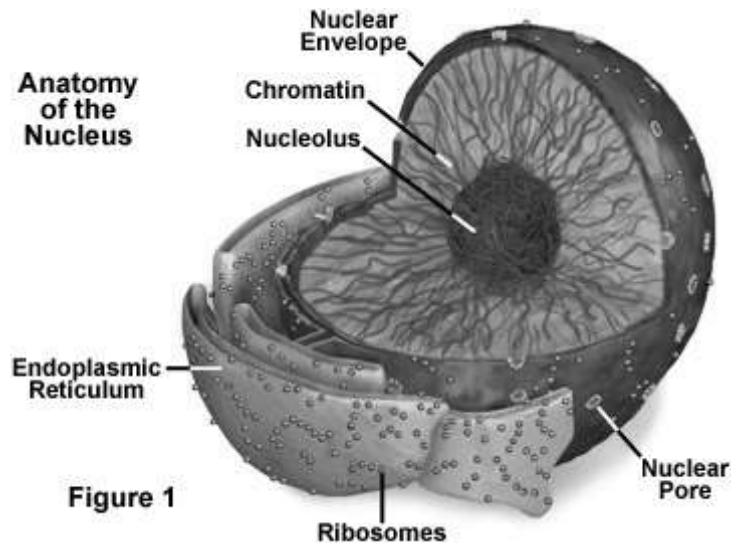
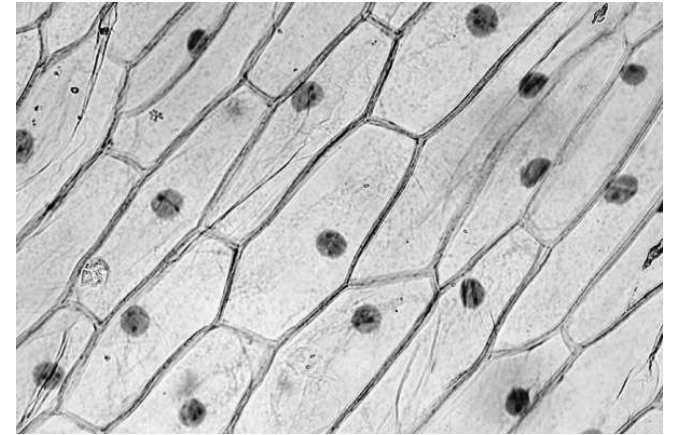
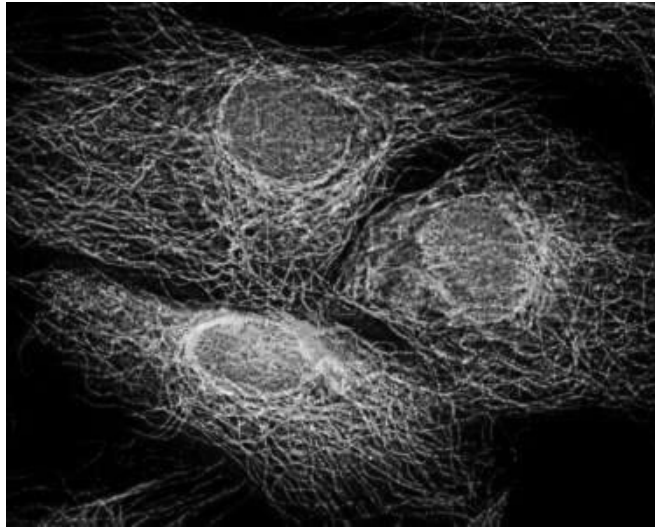
- Eukaryotic cells contain well defined cellular organelles such as:
 - Nucleus
 - Mitochondria
 - Endoplasmic reticulum
 - Golgi apparatus
 - Peroxisomes
 - Lysosomes

NUCLEUS

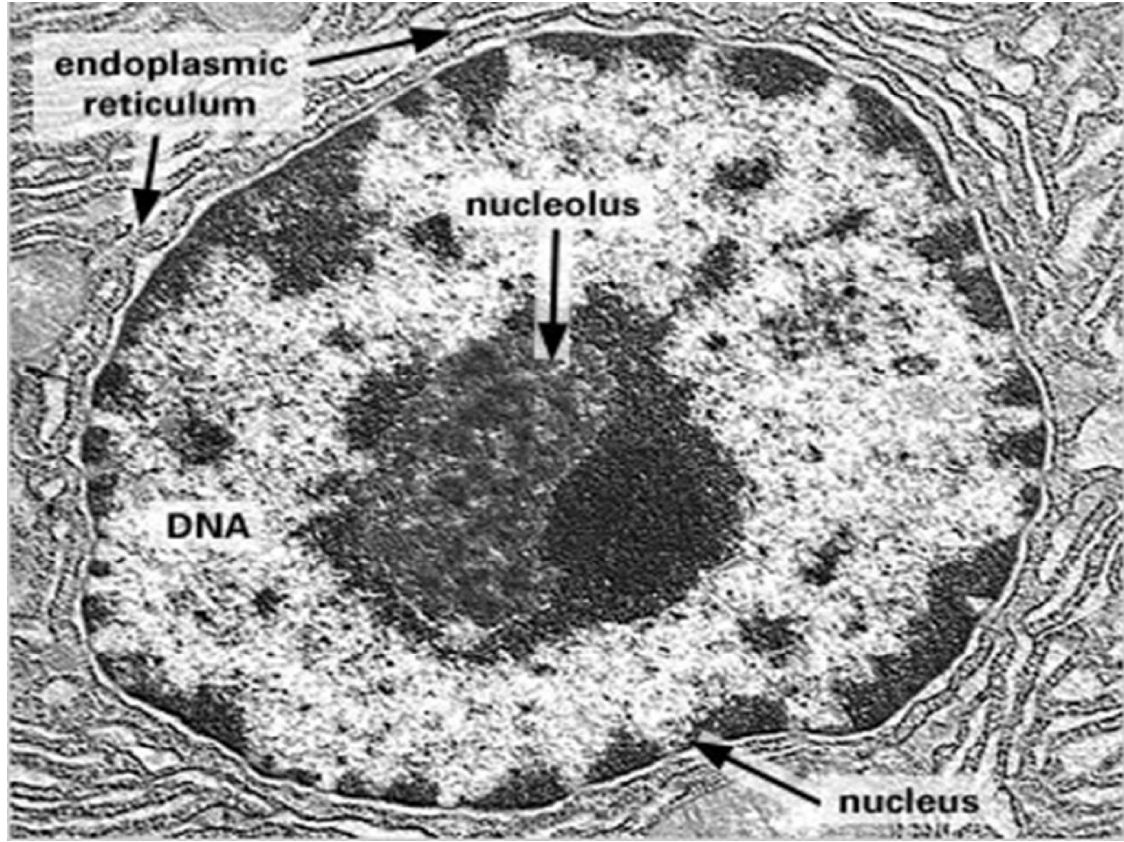
The nucleus is the largest cellular organelle in animals. In mammalian cells, the average diameter of the nucleus is approximately 6 micrometers (μm), which occupies about 10% of the total cell volume. The viscous liquid within it is called nucleoplasm, and is similar in composition to the cytosol found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



- 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



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.

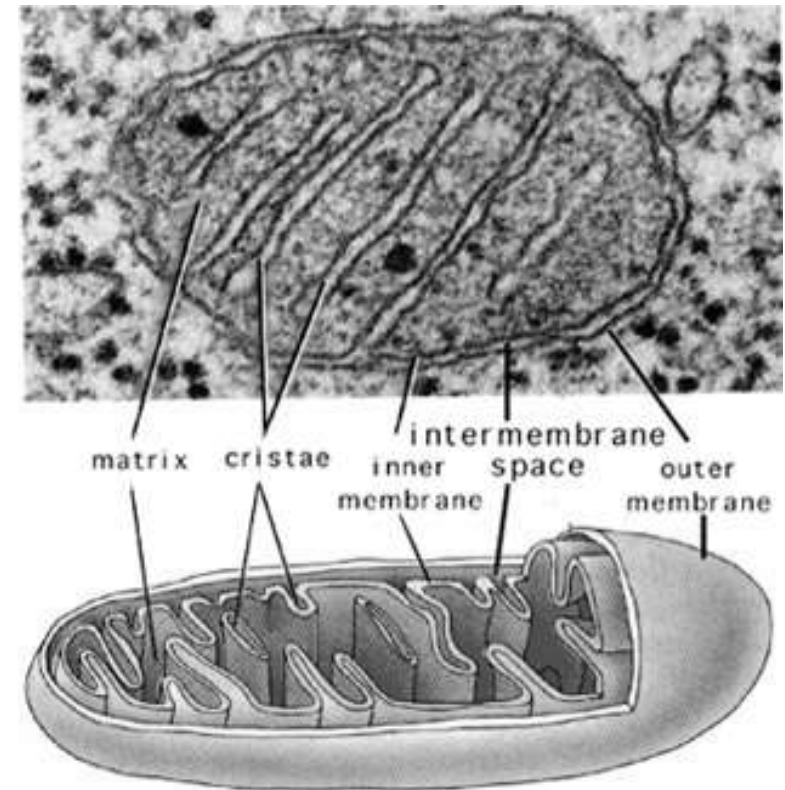
MITOCHONDRIA

- In electron micrographs of cells, mitochondria appears as – rods, spheres or filamentous bodies.
- Size: $0.5\mu\text{m}$ - $1\mu\text{m}$ in diameter
up to $7\mu\text{m}$ 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.

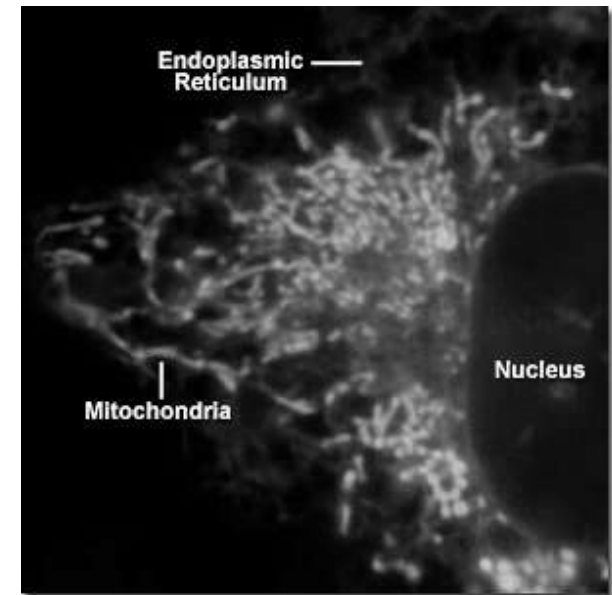
Matrix:

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

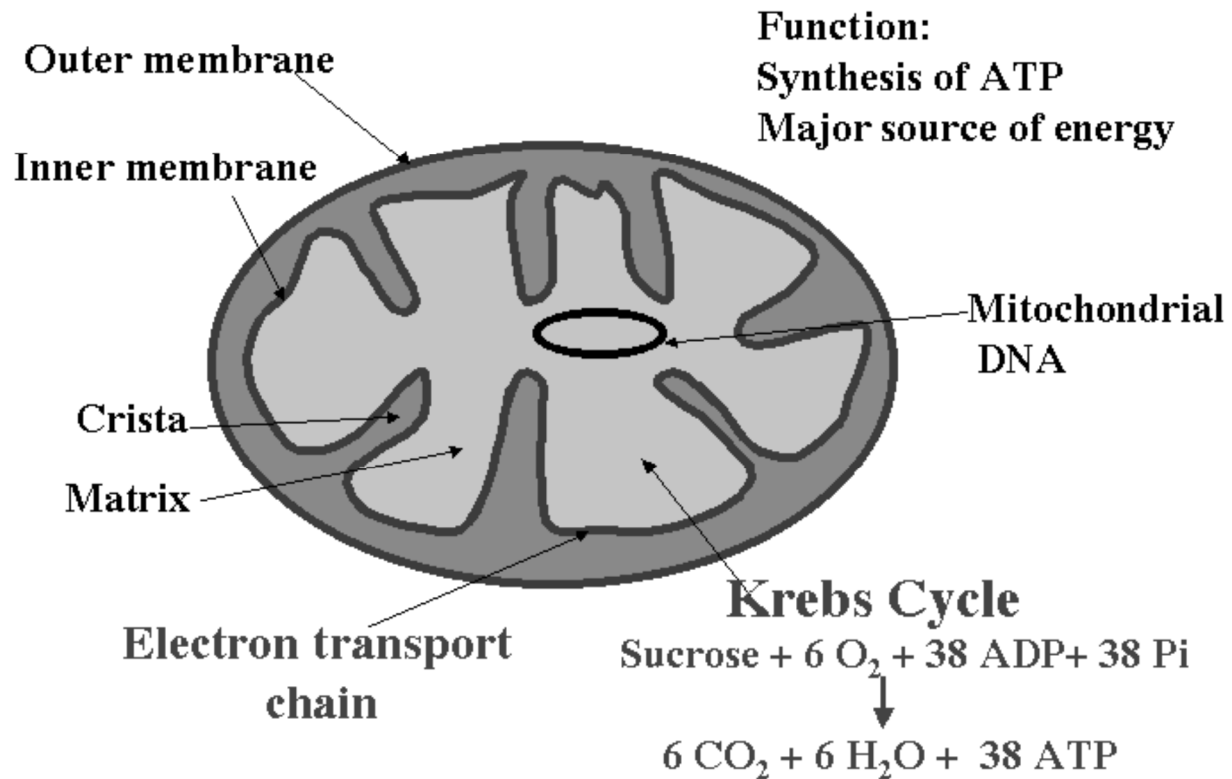
Biochemistry point of view

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



- 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.

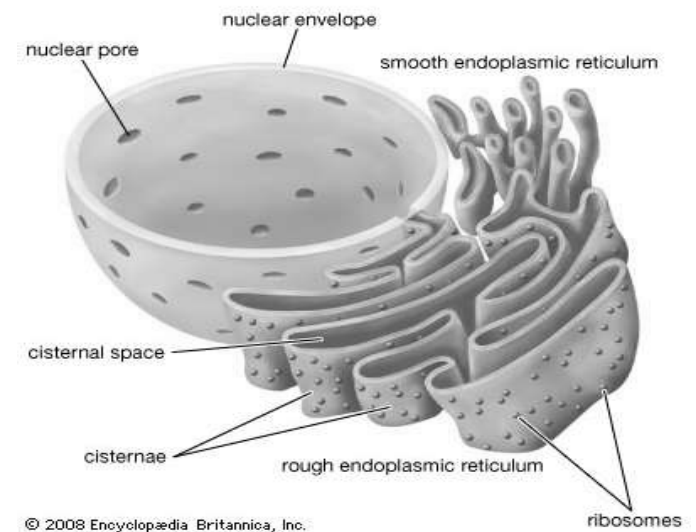
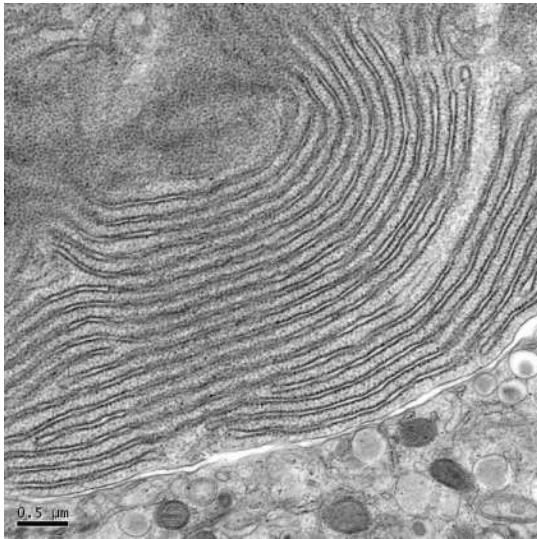
- Mitochondria have a role in its own replication- they contain copies of circular DNA called mitochondrial DNA, this DNA have information for 13 mitochondrial proteins and some RNAs. This is DNA inherited from mothers.

- 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.

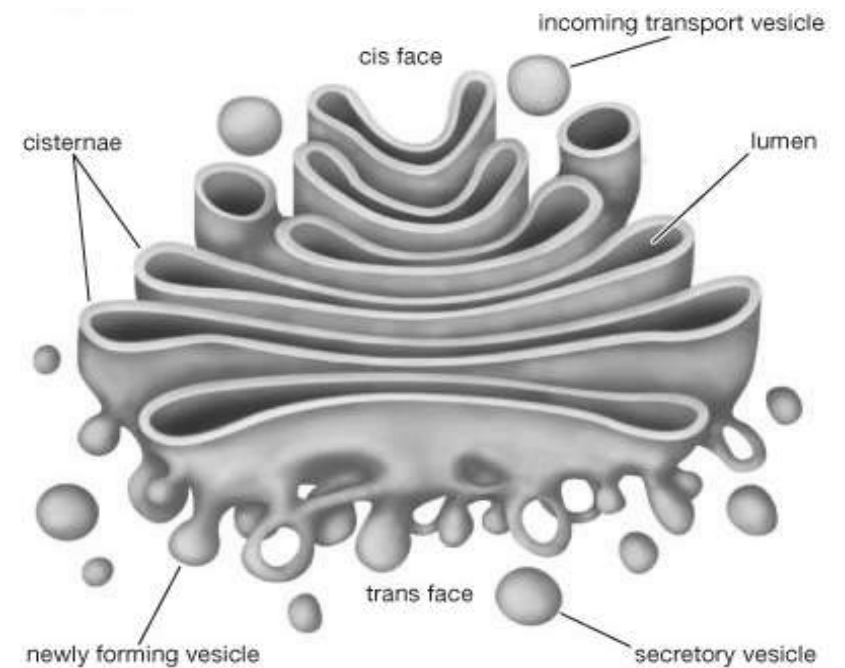
Smooth Endoplasmic Reticulum

- 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.

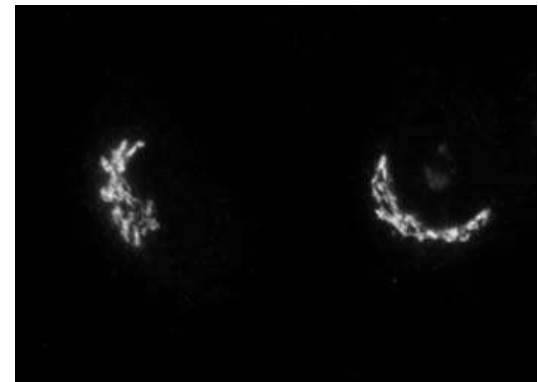
GOLGI APPARATUS

- 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.



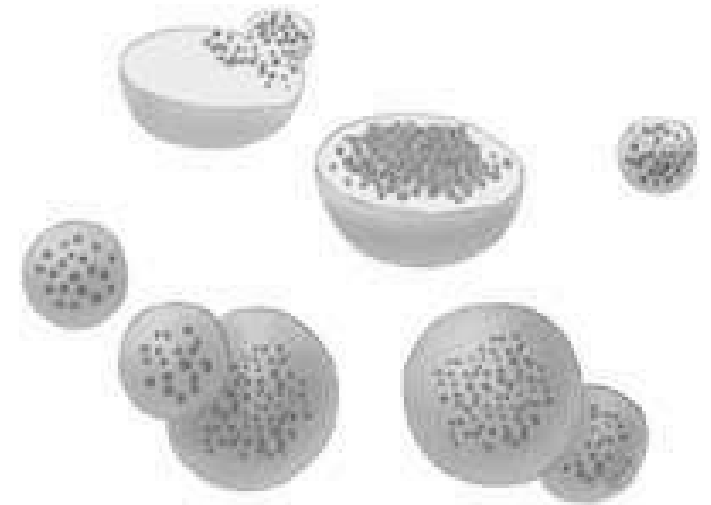
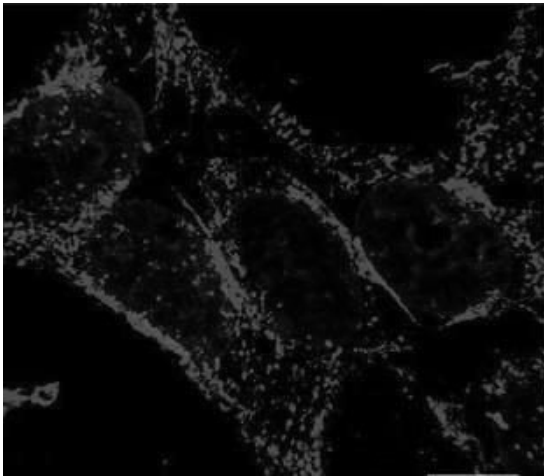
Biochemistry point of view

- Enzymes in golgi complex transfer carbohydrate units to proteins to form of glycoproteins, 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).



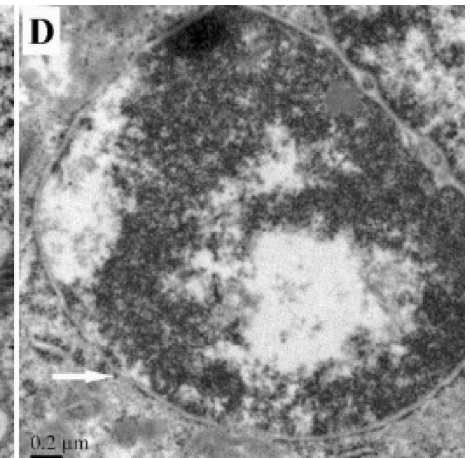
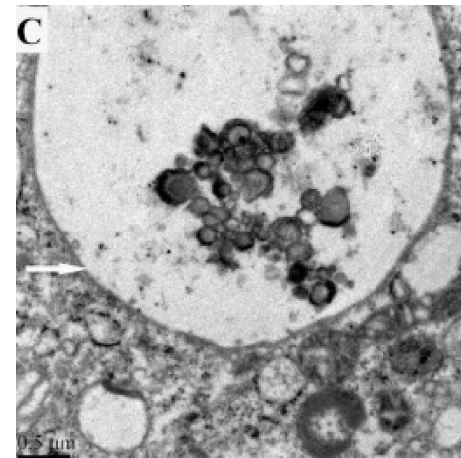
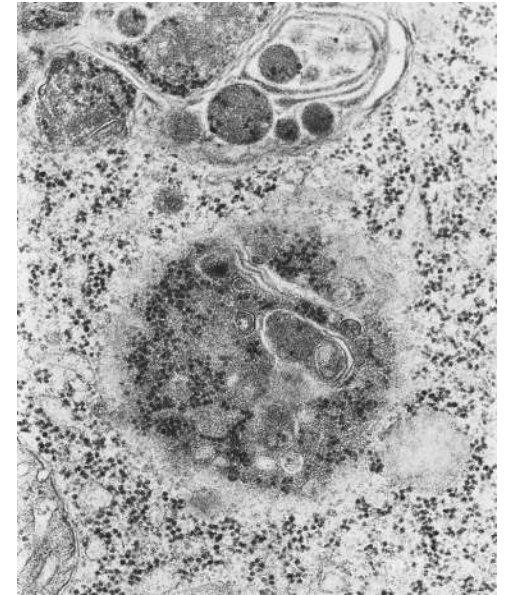
LYSOSOMES

- 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

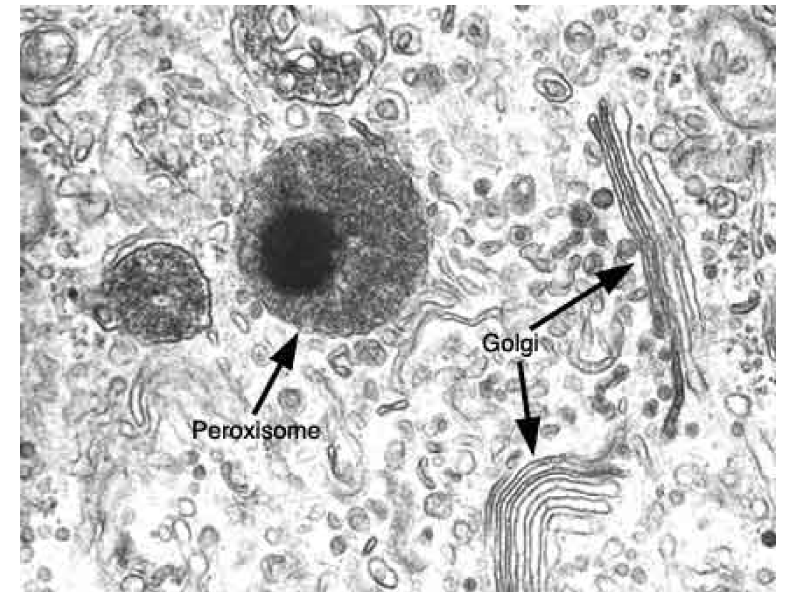
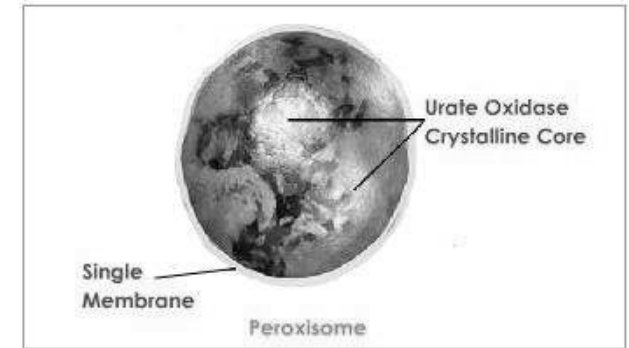
- The enzyme content varies in different tissues according to the requirement of tissues or the metabolic activity of the tissue.
- Lysosomal membrane is impermeable and specific translocators are required.
- Vesicles containing external material fuses with lysosomes, form primary vesicles and then secondary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