CELL BIOLOGY

Mitochondria

- Mitochondria are membrane-enclosed organelle found in most eukaryotic cells.
- It is described as "cellular power plants" because they generate Adenosine triphosphate (ATP).
- Many cells have only a single mitochondrion.
- Some cells contain several thousands of mitochondria.

Significance of Mitochondria

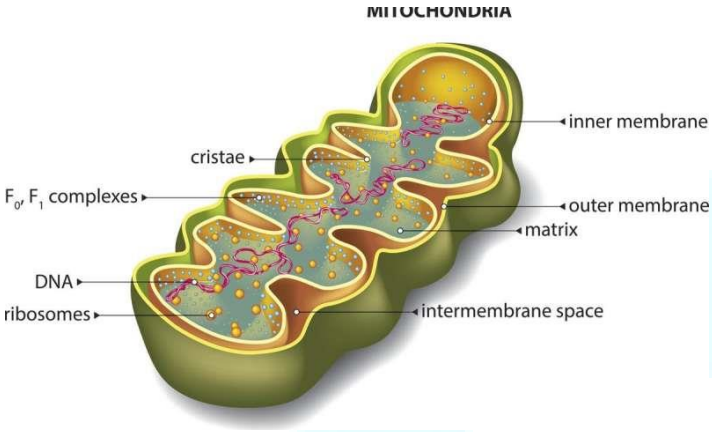
Mitochondria are also involved in

- ATP generation
- Cell signalling
- Cellular differentiation
- Cell death
- Control of the cell cycle, cell growth

Structure of Mitochondria

- A Mitochondrion contains outer and inner membrane composed of phospholipid bilayers and proteins.

- There are five distinct compartments within the mitochondrion.
- They are
  1. The outer mitochondrial membrane
  2. The intermembrane space (the space between outer and inner membrane)
  3. The inner mitochondrial membrane
  4. The cristae space (formed by the infoldings of inner membrane)
  5. The matrix (space within the inner membrane)



Outer Mitochondrial Membrane

- It encloses the entire organelle.
- It contains large number of integral proteins called Porins.
- These porins forms channels that allow molecules to freely diffuse from one side of the membrane to the other.

Inter Membrane Space

- It is the space between outer and inner membrane.
- The concentration of small molecules such as ions and sugars in the intermembrane space is same as the cytosol.
- But protein composition of this space is different from composition of cytosol.
- Protein localized to the intermembrane space is cytochrome C.

Inner mitochondrial membrane

- The inner membrane encloses a cavity,the inner chamber.
- Outer surface of the inner membrane is called C face or cytosol face.
- Inner surface facing the matrix is called M face or Matrix face.
- Inner membrane is rich in an unusual phospholipid, Cardiolipin.
- Cardiolipin helps to make the inner membrane impermiable.
- The inner membrane doesn't contain porins.

- It is highly impermeable to all molecules.

Proteins of inner mitochondrial membrane

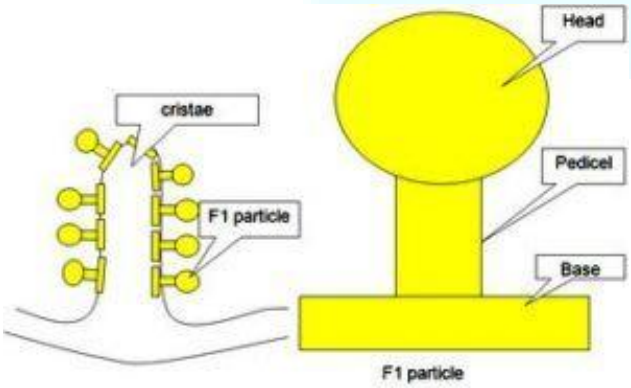
- The inner mitochondrial membrane contains proteins with five types of functions
    1. Redox reaction proteins of oxidative phosphorelation
    2. ATP synthase, which generates ATP in the matrix
    3. Specific transport proteins that regulate metabolite passage into and out of the matrix
    4. Protein import machinery
    5. Mitochondria fusion and fission proteins.

Cristae

- The inner mitochondrial membrane is compartmentalized into numerous folds called Cristae.
- It increases the surface area of the inner mitochondrial membrane.
- Cristae enhances the ability to produce ATP.
- It can affect overall chemi-osmotic function.

F1 particle or Oxysomes

- Cristae are studded on the M face with small round bodies known as F1 particles.
- Known as Fernandez Mora particle or Oxysomes.
- Placed at a regular interval of 10nm.
- They are also called elementary parties, inner membrane subunits or electron transport particles (ETP).



Structure of F1 particle

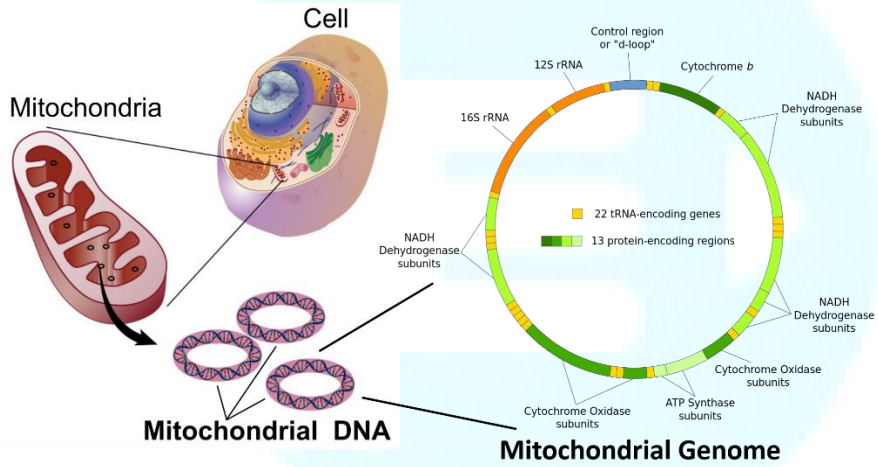
- Each F1 particle has got a base piece, a stalk and a head piece.
- The base piece is a part of the inner membrane.

- Base contains the enzyme of respiratory chain or electron transport series.
- The head piece has 8.5nm diameter.
- Head contains a special ATPase involved in the coupling of oxidation and phosphorylation.

Mitochondrial matrix

- The matrix is the space enclosed by the inner membrane.
- It contains about 2/3 of the total protein in a mitochondrion.
- Role = production of ATP with the aid of the ATP synthase.
- The matrix contains a highly concentrated mixture of hundreds of enzyme, special mitochondrial ribosomes, tRNA, and several copies of the mitochondrisl DNA genome.

Mitochondrial DNA



- Mitochondria have their own genetic material.
- It has the machinery to manufacture their own RNAs and proteins.
- Mitochondrial DNA (mtDNA) molecule is circular about 5 micro meter long.
- It appears as a highly twisted double stranded molecule.
- Mitochondrial DNA can self-replicate and give rise to several copies.
- It has a higher G-C content and hence higher density.
- Three types of RNA have been isolated from mitochondria, 23S, 16S and 4S.
- Mitochondria also contains ribosomes.
- These have a sedimentation coefficient of 55S with 35S and 25S subunits.
- With the help of these mito-ribosomes, structural proteins are synthesized in the mitochondria.

ENTRI

Bioenergetics and mitochondria

- The most prominent role of mitochondria is to produce ATP.
- Mitochondria are known as the "power houses " of the cell.
- Reactions involved in ATP production is collectively known as the Krebs cycle.
- It is also known as Citric acid cycle or Tricarboxylic acid (TCA) cycle.
- This is followed by the Oxidative phosphorylation or Electron transfer series.
- The Krebs cycle takes place in the mitochondrial matrix.
- The mechanism of phosphorylation are integrated within the molecular structure of the inner mitochondrial membrane.
- Five big protein complexes are involved in ETC.
    1. Complex I (NADH dehydrogenase)
    2. Complex II (Succinate dehydrogenase)
    3. Complex III (Ubiquinol-Cytochrome C reductase)
    4. Complex IV (Cytochrome C oxidase)
    5. Complex V (ATP synthase)

Endosymbiotic theory of mitochondria

- Mitochondria have many features in common with prokaryotes.
- They are thought to be originally derived from the endosymbiotic prokaryotes.
- A mitochondrion contains DNA.
- DNA circular structure is also found in prokaryotes.
- Genetic code is similar to that of Proteobacteria.
- This suggests that their ancestor, the so-called proto-mitochondrion, was a member of the Proteobacteria.
- The endosymbiotic relationship of mitochondria with their host cell was popularized by Lynn Marguils.
- Hypothesis suggests that mitochondria descended from bacteria that somehow survived endocytosis by another cell,and became incorporated into the cytoplasm.
- The incorporation of symbiotes would have increased the number of environments in which these cells could survive.
- This symbiotic relationship probably developed 1.7 to 2 billion years ago.