CC4: Cell Biology
Unit 3: Cytoplasmic organelles II
Mitochondria: Structure, Semi- autonomous nature

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Introduction to Mitochondria in Cell:

Mitochondria are membrane bound cell organelles, associated with cellular respiration, the source of energy, being termed as power houses of cell. Mitochondria, discovered by Benda (1898), are present in eukaryotic cells. These are bean-shaped organelles, 1 to 10 µm long and about 0.5 µm wide, occur free in the cytoplasm.

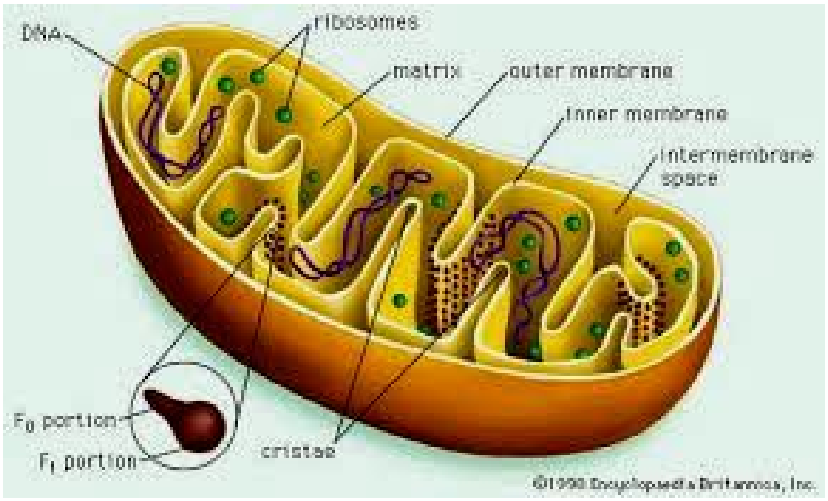
Origin of Mitochondria in Cell:

The life span of a mitochondrion is 5-10 days.

There are three views regarding the origin of mitochondria:

(a) Origin from various cell membranes,
(b) By division of fully formed mitochondria and
(c) De novo origin.

Structure of Mitochondria in Cell:



The mitochondrion is bounded by two membranes, the outer membrane and the inner membrane (Fig. 2.50). Both the outer and the inner mitochondrial membranes are about 60-70A thick. The outer membrane contains more phospholipid and cholesterol than the inner membrane. Phosphatidylcholine is the predominant lipid of the outer membrane while the inner membrane contains most of the diphosphatidylglycerol (cardiolipin) of the mitochondrion.

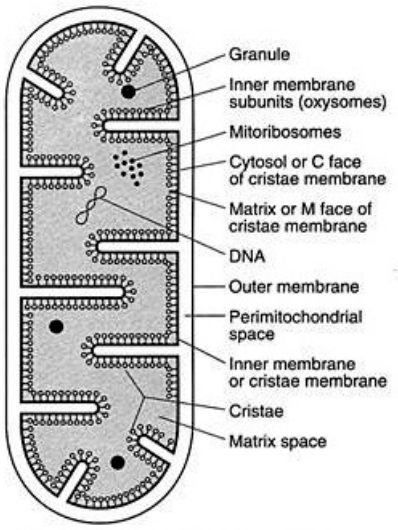


Fig: A mitochondrion in sectional view

The space between the two membranes is called the outer chamber or inter-membrane space or peri-mitochondrial space. It is filled with a watery fluid, and is 40-70A in width. The space bounded by the inner membrane is called the inner chamber or inner membrane space.

The inner membrane space is filled with a matrix which contains dense granules, mitoribosomes (70S) and circular mitochondrial DNA and Krebs cycle enzymes. The sides of the inner membrane facing the matrix and the outer chamber are respectively called M-face and C-face.

The outer membrane is smooth while the inner membrane is thrown up into a series of folds, called cristae mitochondrial, which project into the inner chamber (Fig. 2.51 A). The cavity of the cristae is called the inter-cristae space, and is continuous with the inter- membrane space.

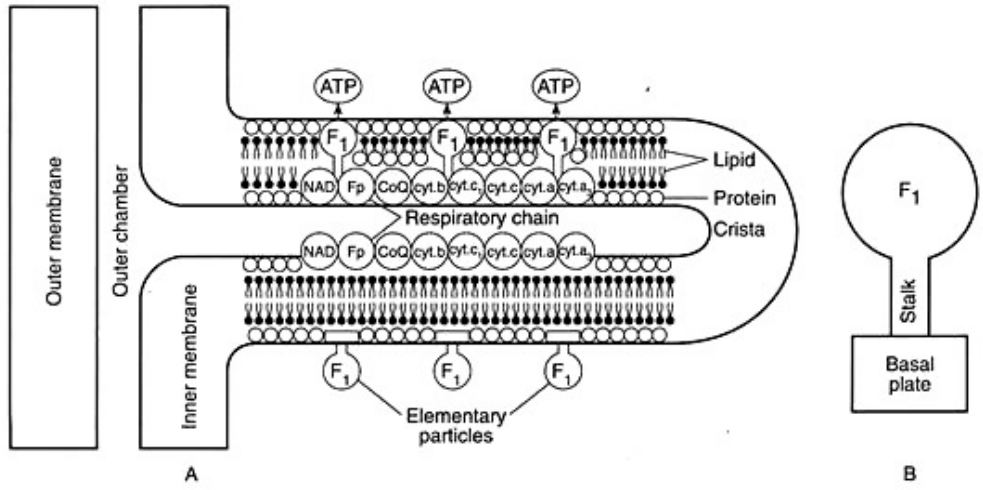


Fig. 2.51: A. Mitochondrial crista and B. Elementary particle

Associated with the inner membrane are several thousand small particles which have been called elementary particles or subunits of Fernandez-Moran, or $F_0 - F_1$ complex or ATPase complex or oxysomes. Each particle consists of a base-piece, a stalk, a headpiece. The particles are spaced about 100Å intervals. The headpiece is 75-1 OOÅ in diameter, and the stalk about 50Å in length (Fig. 2.51 B).The respiratory chain, consists of a series of protein, located in the inner membrane of mitochondria. Five complexes (Table 2.5) have been identified: four of them (I -IV) constitute electron transport system and the rest (V) is the ATP synthesizing system.

Table 2.5: Components of respiratory chain

Complex I	:	NADH/NADPH : CoQ reductase
Complex II	:	Succinate : CoQ reductase
Complex III	:	Reduced CoQ ($CoQH_2$) : cytochrome c reductase
Complex IV	:	Cytochrome c oxidase
Complex V	:	ATPase (ATP synthesizing system)

Elementary particles contain complex V while other components are embedded within the inner membrane (Fig. 2.52).

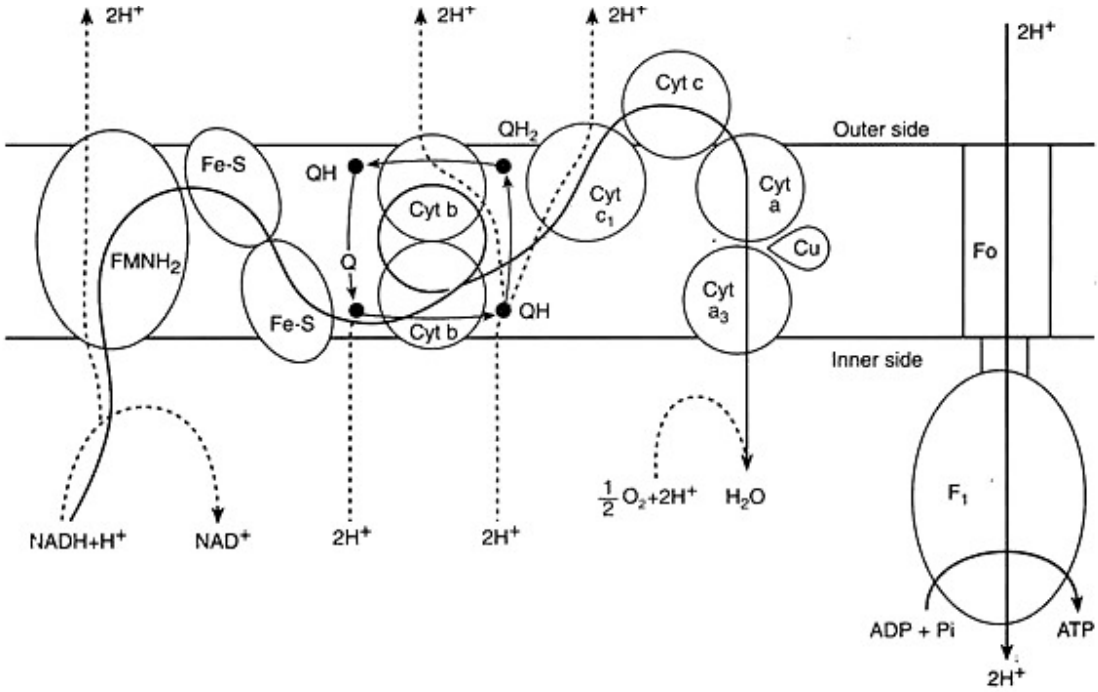


Fig. 2.52: Components of the respiratory chain in the inner membrane of the mitochondrion (after Hinkle and McCarty, 1978)

Function of Mitochondria in Cell

Mitochondria supply nearly all the required biological energy. Only the mitochondria are fully capable of converting pyruvic acid to carbon dioxide and water. They are the respiratory centres of the cell. The enzymes for Krebs cycle are found in the matrix of the mitochondrion. The enzymes for electron transport are located in the inner membrane of mitochondrion.

The ATP molecules produced as a result of cellular respiration accumulate in the mitochondria. A set of enzymes that control synthesis of lecithin and phosphatidyl ethanolamine from fatty acids, glycerol and nitrogenous bases is present in most mitochondria. Mitochondrial genes control some hereditary characters, e.g., male sterility in maize.

Semi-autonomy

There is no doubt that the mitochondria exhibit certain degree of autonomy:

(a) Presence of mtDNA (circular);

(b) Evidence of DNA dependent RNA synthesis;

(c) Presence of mitoribosomes (70S);

(d) Evidence of protein synthesis;

(e) Contain genes controlling heredity (male sterility in maize); and

(f) Can multiply by division.

According to symbiotic hypothesis, the host cell is an anaerobic organism which derives energy by anaerobic respiration or glycolysis, and the parasite mitochondrion (aerobic bacterium) contains enzymes for Krebs cycle and respiratory chain and thus able to carry on respiration and oxidative phosphorylation.