Mitochondria

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Introduction

Mitochondria are commonly called the "Power house" of the cell. Benda (1897) was the first to coin the term mitochondrion. In 1953, Palade and Sjostrand independently described the ultrastructure of mitochondria.

Morphology

The mitochondria are small granules which are rod shaped with a diameter of 0.2µ too.5µ**.** Their number may vary from 50 to 50,000 in different kinds of cells and are found scattered in cytoplasm.

Ultrastructure:

- Mitochondria are bounded by an envelope consisting of two concentric membranes, the outer and inner membranes. The membranes are composed of phospholipids and protein.
- At places outer and inner membranes come in contact This site is adhesion site-for transfer of materials from outside to inside or vice versa.
- The space between the two membranes is called perimitochondrial space. Usually, it is 60-100Å wide. It extends into the space of cristae. Space contains a fluid having a few enzymes.

- A number of invaginations occur in the inner membrane; they are called cristae (Fig. I). The space on the interior of the inner membrane is called matrix.

Outer Membrane:

- The outer membrane has special proteins known as porins.

- It is freely permeable to nutrient molecules, ions, energy molecules like the ATP and ADP molecules.
- It is 60 to 75 (Å) thick
- The mitochondrial outer membrane contains a number of enzymes and protein

Inner Membrane:

- It lies within the outer membrane and nearly 60Å thick.
- The inner membrane contains large number of proteins which are involved in electron transfer (respiratory chain) and oxidative phosphorylation .
- The respiratory chain is located within the inner membrane, and consists of pyridine nucleotides, flavoproteins, cytochromes, iron-sulphur proteins and quinones.

- Besides its role in electron transfer, and phosphorylation, the inner membrane is also the site for certain other enzymatic pathways, such as, steroid (hormone) metabolism.

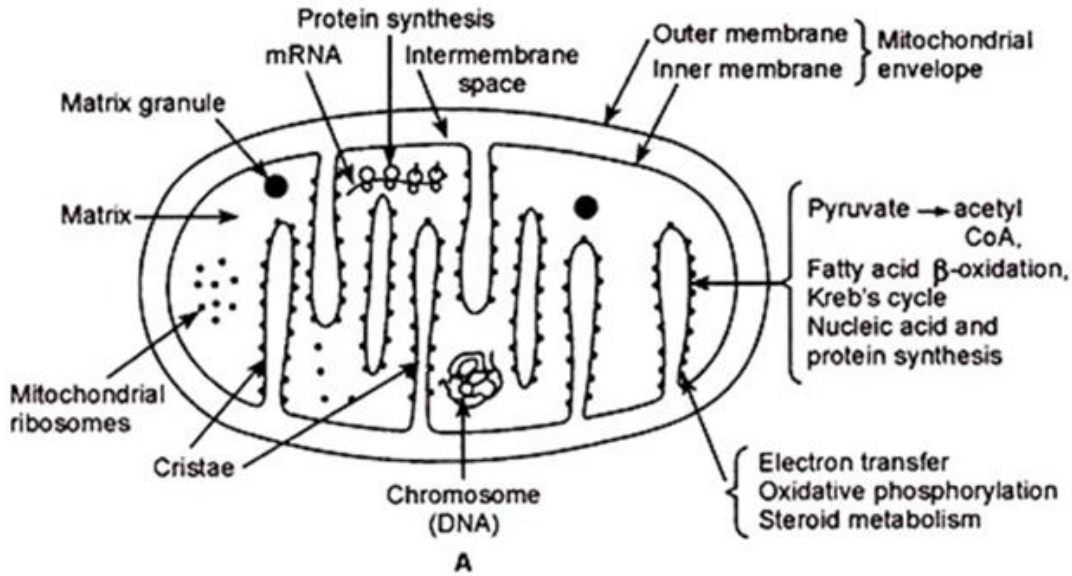


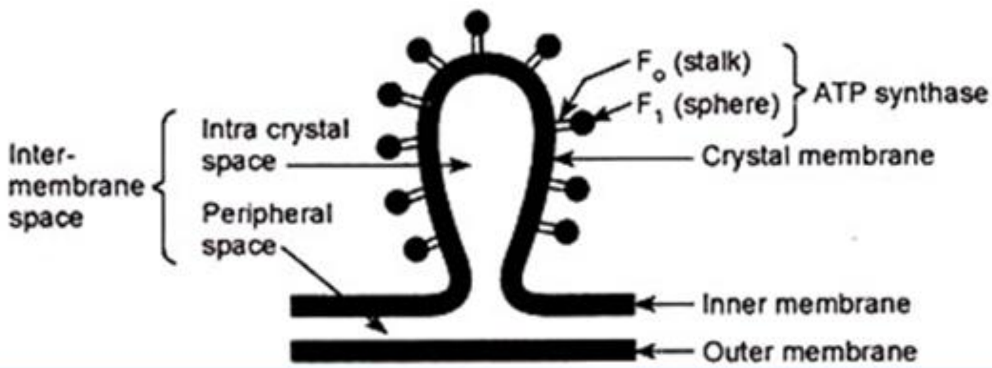
Fig.I. Diagrammatic representation of mitochondrial ultrastructure.A.Mitochondrial cross section showing various parts.

Cristae

- The inner membrane folds inwards to form finger-like projection known as cristae which help to increase the surface area for absorption.

- Cristae possess small tennis-racket like particles called elementary particle,F_0 –F_1 prticles or oxisomes.
- Each oxisome has a head ,a stalk and a base.
- The base (F_0 subunit) is11nm long, the stalk 5 nm long.
- The head (F_1 subunit) has a diameter of 8.5 nm. It contains ATP-ase. and therefore, the centre of ATP synthesis during oxidative phosphorylation. Enzymes of Electron transport in inner membrane in contact with elementary particles.

Detailed structure of a crista



Chemical composition

Chemically, the mitochondria are lipoprotein-aceous in nature. They consist of about 60-65% proteins and 35-40% lipids, mainly phospholipids. The presence of RNA and a little amount of DNA has also been reported.

Matrix:

The interior of mitochondrion is called matrix. It is a complex mixture of proteins and enzymes . It has granular appearance in electron micrographs. The matrix contains enzymes and factors for Krebs cycle, **pyruvate dehydrogenase** and the enzymes involved in β-oxidation of fatty acids. Besides above, matrix also contains naked DNA, RNA, 70s ribosomes and proteins involved in protein and nucleic acid synthesis

Active and Inactive State

Active state, also called condensed state because of reduced size of core. In this state mitochondria are actively engaged in krebs cycle, electron transport, oxidative phosphorylation.**Inactive state**,also called orthodox state. Respiratory chain and ATP synthesis is reduced. Matrix enlarged ,outer chamber narrow.

Autonomy of mitochondria

Mitochondria have their own DNA which can replicate independent of the nuclear DNA of cell. Mitochondrial DNA produces its own mRNA, tRNA, rRNA and posses their own ribosome. Structure and functioning are partially controlled by nucleus

Biogenesis of Mitochondria:

Mitochondria originate by growth and division of pre-existing mitochondria which are known as **"pro-mitochondria".** In the presence of O_2, cristae and other components of mitochondria develop so that pro-mitochondria convert into mitochondria.

Function of Mitochondria:

1. **Oxidation of food:**
   - Mitochondria is regarded as the power house of the cell as it is the site of respiration. In mitochondria the krebs cycle of respiration takes place The general formula for glucose oxidation is,
   - $C_6H_{12}O_6 + 6O_2$ ———-> $6CO_2 + 6H_2O$ + 686 kcal
   - Glucose is degraded into two pyruvate molecules through glycolysis which occurs in the cell sap (cytosol). Further steps in oxidation of pyruvate take place in the mitochondria.

   - Pyruvate is converted to acetyl-Coenzyme A (acetyl-CoA) which is then metabolised through the Krebs cycle, also called the citric acid cycle or tricarboxylic acid cycle. In this cycle, energy is liberated and CO_2 is produced.
   - Some of the released energy is used to produce ATP, while a major part is conserved in the form of reduced coenzymes NADH and $FADH_2$ (FAD = flavinadenine dinucleotide).

   - The energy conserved in NADH and $FADH_2$ is released by re-oxidizing them into NAD^+ and FAD, respectively; the energy so obtained is utilized to produce ATP (oxidative phosphorylation).

- This process occurs in different steps in a strict sequence called electron transfer chain or respiratory chain located in the cristae In complete oxidation of one glucose molecule, 6 molecules of oxygen are utilized resulting in the production of 6 carbon dioxide and 6 water molecules; in addition, energy is released .
- The maximum number of ATP molecules produced during complete oxidation of one glucose molecule is 36 (Table I)

Table. I.The number of ATP molecules produced during the complete oxidation of one glucose($C_6H_{12}O_6$).

Source	Net ATP produced from substrate level phosphoryation	Production of reduced coenzyme	Maximum number of ATP molecules produced from reduced coenzyme	Total number of ATP molecules produced
I. Glycolysis	2ATP			2
(glucose→2 pyruvate)		2 NADH	4*	4
II. 2 pyruvate→ 2 acetyl-CoA		2 NADH	6**	6
III. Kreb's cycle (2 turns)		6 NADH	18**	18
		2FADH$_2$	4***	4
	2ATP			2
Total				36

2. **Metabolism of fat.**
3. **Development of microfibrils.**
4. **Perform the function of secretion.**