Mitochondria

Mitochondria are cell organelles which take part in oxidative phosphorylation and Krebs cycle of aerobic respiration. They are called power houses of cell because they are the major centers of release of energy in the aerobic respiration.

They were first observed by Kolliker in 1850. Benda (1897) gave the name mitochondria (Gk. mitos- thread, chondrion- grain) to the organelles. They are absent in prokaryotes, anaerobic eukaryotes and are secondarily lost in the red blood corpuscles of mammals.

Shape and Size:

Commonly mitochondria are cylindrical in outline. The size of the mitochondria is variable. Normally, they have a length of 1.0-4.1 µm and a diameter of 0.2-1.0 µm (average 0.5 µm). Chemical constituent include Proteins (60-70%), Lipids (25-35%), RNA (5-7%), DNA (trace amount) and trace amount of Manganese and Calcium phosphate.

Structure:

A mitochondrion contains two membranes. Each of them is 60-75Å in thickness.

Outer Membrane:

The membrane is smooth. It is permeable to a number of metabolites. It is due to presence of protein channels called porins or minute pores. A few enzymes connected with lipid synthesis are located in the membrane. It is poorer in proteins as compared to inner membrane.

Inner Membrane:

It is permeable to only some metabolites. It is rich in double phospholipid called cardiolipin (having four fatty acids) which makes the membrane impermeable to ions. Protein content is also high, being 70—75% of total components. The inner membrane is in-folded variously to form involutions called cristae. They increase the physiologically active area of the inner membrane. The cristae are generally arranged at right angles to the longitudinal axis of the mitochondrion. They are tubular (most plant cells) or plate like (most animal cells) or vesicle-like (Euglena). A crista encloses a space that is continuation of the outer chamber. The density of cristae indicates the intensity of respiration.

Inner membrane as well as its cristae possess small tennis-racket like particles called elementary particles, F_0 –F_1 particles or oxysomes (= oxisomes).

A mitochondrion contains 1×10^4–1×10^5 elementary particles. Each particle has a head, a stalk and a base. The base (F_0 subunit) is about 11nm long and 1.5 nm in thickness. The stalk is 5 nm long and 3.5 nm broad.

The head (F_1 subunit) has diameter of 8.5 nm. Elementary particles function as ATP-ase. They are, therefore, the centres of ATP synthesis during oxidative phosphorylation. Both head and stalk constitute F_1. F_0 or base has a roter and a stator.

A channel occurs between roter and stator for passage of protons (H^+). Stator is connected to head region by an arm. Enzymes of electron transport are located in the inner membrane in contact with elementary particles.

At places, outer and inner mitochondrial membranes come in contact. They are called adhesion sites. Adhesion sites are special permeation regions of the mitochondrion for transfer of materials from outside to inside and vice versa.

Outer Chamber (Peri-mitochondrial Space):

The chamber is the space that lies between the outer and inner membrane of the mitochondrial envelope. Usually, it is 60-100Å wide. It extends into the spaces of the cristae. It contains a fluid having a few enzymes.

Inner Chamber:

It forms the core of the mitochondrion. The inner chamber contains a semi-fluid matrix. The matrix has protein particles, ribosomes, RNA, DNA (mitochondrial or mtDNA), enzymes of Krebs or TCA cycle (except succinate dehydrogense which is membrane based), amino acid synthesis and fatty acid metabolism, crystals of calcium phosphate and manganese. Mitochondrial ribosomes are 55S to 70S in nature. They thus resemble the ribosomes of prokaryotes. DNA is naked. It is commonly circular but can be linear. DNA makes the mitochondrion semi-autonomous.

Autonomy or independence in functioning:

1. Mitochondria have their own DNA which can replicate independently.
2. Mitochondrial DNA produces its own mRNA, tRNA and rRNA.
3. The organelles possess their own ribosomes.
4. Mitochondria synthesize some of their own structural proteins.
5. The organelles synthesize some of the enzymes required for their functioning.
6. They grow internally.
7. New mitochondria develop by division/binary fission of pre-existing mitochondria.

However, mitochondria are not fully autonomous. Both their structure and functioning are partially controlled by nucleus of the cell and availability of materials from cytoplasm. Mitochondria are believed to be symbionts in the eukaryotic cells which became associated with them quite early in the evolution.

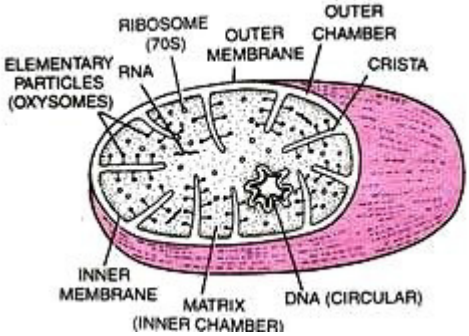
Functions:

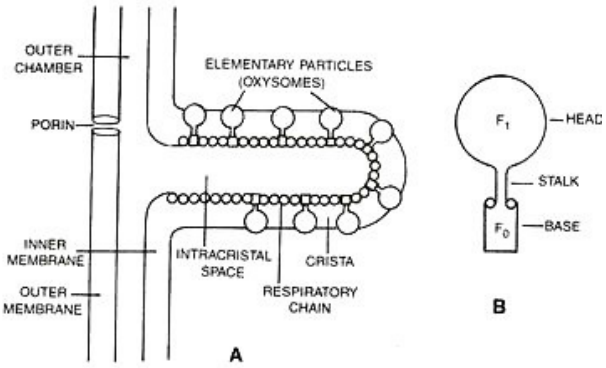
1. Food stuffs or respiratory substrates are completely oxidized to carbon dioxide and water. Energy liberated in the process is initially stored in the form of reduced coenzymes and reduced prosthetic groups.

The latter soon undergo oxidation and form energy rich ATP that comes out of mitochondria and helps perform various energy requiring processes of cell like muscle contraction, nerve impulse conduction, biosynthesis, membrane transport, cell division, movement, etc. Because of the formation of ATP, the mitochondria are called power houses of the cell.

2. Mitochondria provide important intermediates for the synthesis of several bio-chemicals like chlorophyll, cytochromes, pyrimidine's, steroids, alkaloids, etc.

3. The matrix or inner chamber of the mitochondria has enzymes for the synthesis of fatty acids. Enzymes required for elongation of fatty acids have been found in outer mitochondrial chamber.
4. Synthesis of many amino acids occurs in the mitochondria. The first formed amino acids are glutamic acid and aspartic acid. They are synthesized from a-ketoglutaric acid and oxaloacetic acid respectively. Other amino acids are produced by transformation and transamination or transfer of amino group (—NH2) from glutamic acid and aspartic acid.
5. Mitochondria may store and release Calcium when required.
6. An organism generally receives mitochondria from its mother (maternal inheritance).





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