Quadrant II –Notes

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Module No: 18

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Mitochondria (singular: mitochondrion) are a double membrane bound organelle found in cytoplasm of eukaryotic cells. These are small granular or filamentous bodies. The word mitochondrion comes from the Greek, *Mitos* – thread, *chondrion* – granule or grain like. Kolliker first observed mitochondria as granular structures in striated muscles (1850). Richard Altmann (1892) named this organelle the bioplast and he suggested that bioplast were independent organelles. The term mitochondria was coined by Carl Benda (1898).

Mitochondria are called as "Power houses of the cell" since they generate and provide chemical energy adenosine triphosphate (ATP) to the cell. They are associated with cellular respiration and are the sources of energy. They play a major role in breaking down nutrients and generating energy rich molecules.

MORPHOLOGY OF MITOCHONDRIA

Examination of mitochondria in living cells is somewhat difficult because of their low refractive index. They can be stained differentially with Janus Green and are easily distinguishable.

Size

Mitochondria vary in size. The average length of the mitochondria is 3-4 microns and the average diameter 0.5 to 1.0 micron. Sometimes their length may reach up to 7 micron.

Shape

The shape of mitochondria is variable, but in general these organelles are filamentous or granular. During certain functional stages, other derived forms may be seen (i.e they may change from one form to another depending upon the physiological conditions of the cells).e.g. a long mitochondrion may swell at one end to assume the form of a club. Thus they may be of club, racket, vescicular, ring or round-shape.

The morphology of mitochondria varies from one cell to another, but it is more or less constant in cells of a similar type or in those performing the same function.

Number

The number of mitochondria varies in different cell types. It varies from cell to cell and from species to species. It is however constant for a particular cell type. The number of mitochondria depends upon the metabolic activity of the cell.

Distribution

Mitochondria are in general, uniformly distributed throughout the cytoplasm, but there are many exceptions to this rule. In some case, they occur around the nucleus or in peripheral cytoplasm. The distribution of mitochondria within the cytoplasm should be considered in relation to their function as energy suppliers.

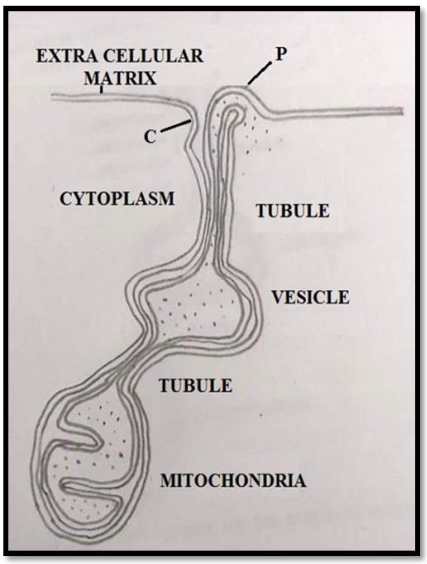
ORIGIN OF MITOCHONDRIA

Following hypothesis are generally discussed:

1) From various membranes

Robertson (1964) has shown that the mitochondria arise by an infolding of the plasma membrane, into which passes a projection from an adjacent part of the membrane. This would result in a double membranes vesicle.

According to him the protuberance (P) passes into the invagination of cell membrane to form a double-membrane lined tubule, which enlarges into a vesicle. Soon from the inner membrane several outgrowth arise to form cristae, thus forming the mitochondria.

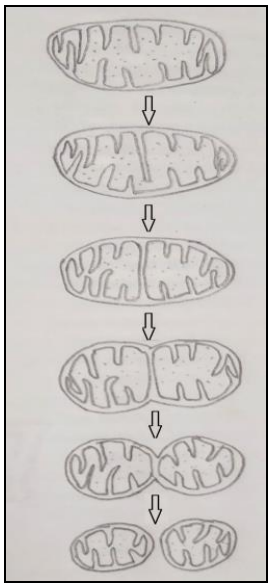


Possible mechanism for the origin of mitochondria from plasma membrane

Hoffman and Gregg (1958) postulated that mitochondria arise from the nuclear membrane and later extend into the cytoplasm.

1) By division of pre-existing mitochondria

Electron microscopic studies of *Neurospora crassa* (Luck, 1963) have shown that mitochondria originated by division of pre-existing mitochondria. Organelle division begins by an inward furrowing of the inner membrane. After elongating, one or more centrally located cristae form a partition by growing across the matrix.



Fission of a mitochondrion by partition formation

3. Prokaryotic Origin or Symbiotic Hypothesis

According to Altmann and Schimber (1980) mitochondria originated from the prokaryotic cells. Mitochondria are intra cellular parasites of the cells which have entered in the cytoplasm of eukaryotic cells and have maintained symbiotic relations with the eukaryotic cells.

This theory is based on the several similarities between bacteria and mitochondria.

- **Morphology** – the general dimensions of bacteria and mitochondria are similar. Rod shaped bacteria are similar in shape to many types of mitochondria.
- **Localization of the respiratory chain** – the inner membrane of the mitochondria is similar to the bacterial plasma membrane with respect to the respiratory chain the projections of the plasma membrane (mesosome) in some bacteria are similar to the cristae of mitochondria.
- **Chemical Constitution**- there is similarity between the lipid composition of bacterial and mitochondrial membranes.
- **DNA structure** – the DNA of both mitochondria and bacteria is circular.
- **Ribosomes** – the small size of mitochondrial ribosomes (55-60S) is comparable to that of bacterial ribosomes (70S) but not with that of non – bacterial ribosomes (80S).
- **Drug sensitivity** – In mitochondria and bacteria, the protein synthesis is inhibited by chloramphenicol but not that of higher cells. This is because the drug can bind with the mitochondrial and bacterial ribosomes, but not with the 80S non bacterial ribosomes.

4. Mitochondrial formation *de novo*

There are several reports of *de novo* synthesis of mitochondria. *De novo* synthesis of mitochondria has been reported in *Neurospora*. Most cases of *de novo* synthesis have been reported in cells undergoing rapid growth. Atardi and Atardi (1967) have suggested that mitochondria may release mRNA which then goes to the Endoplasmic reticulum. Here with the help of the ribosomes it forms the membrane protein. This would result in the apparent *de novo* synthesis of mitochondria.