MITOCHONDRIA

PREFACE => Mitochondria are granular or filamentous - structures present in cells associated with aerobic respiration. They are also referred to as the "POWER HOUSE OF THE CELL"

WORKS DONE ON MITOCHONDRIA :-

1950 x PALADE : Gave the fine structure of mitochondria
1934 x BENSLEY : Isolated the same in the liver cells.
1904 x F. MENES : Described the same in plant cells.
1898 x BENDA : Renamed as MITOCHONDRIA.
1892 x ALTMANN : Named it as Bioplast.
1882 x FLEMMING : Observe the same as thread structures
1850 x KOLLICKER : first observed mitochondria as granular structures.

Size :- Variable and depends on the functional status of the cell. But generally the width is constant about 5 μ. and length 3-4 μ. with a maximum of 7 μ.

Shape :- Variable. It may be granular or filamentous. It may be club shaped or tennis racket shaped.

Number :- Absent in bacteria and in anaerobically respiring cells like RBC of man. By cells with higher rate of metabolism has a higher number of mitochondria.

VII A **COMMENT :-** Number of mitochondria seen in different cells of different organs are different. Some of these are listed below-

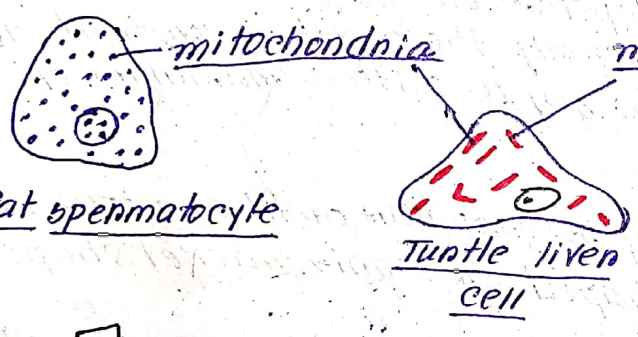
Sea-urchin = 13000 - 14000.
Renal tubule = 300 - 400.
Sperm = 20 - 24.
Oocyte = 300000 (3 lakh)
Chaos chaos = 500000 (5 lakh)

VIII **DISTRIBUTION :-** In general, mitochondria distributed in the cytoplasm of the cell. They may be concentrated at one place as in-

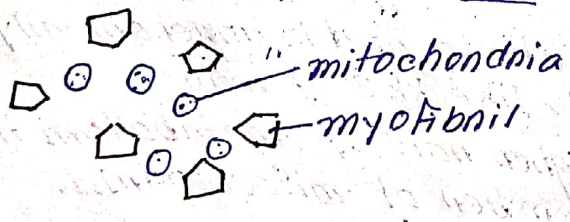
a) Proximal Convoluted Tubule :- Basal region of the cell.
b) Insect Flight muscle :- Between two myofibrils.
c) Leucocytes :- Radially arranged.

Remark :-

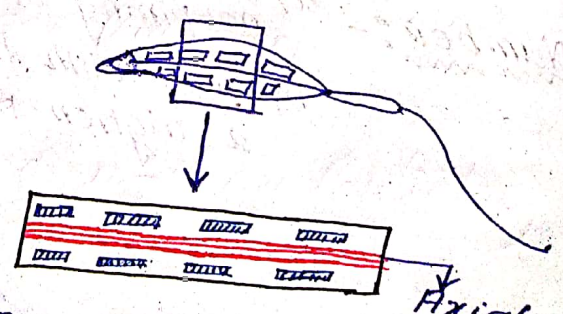
During cell division, mitochondria are concentrated on the spindle.



Rat spermatocyte — Turtle liver cell — Mammal Kidney cell



Insect flight muscle. (showing arrangement of mitochondria)



Arrangement of mitochondria in mammalian sperm

MOVEMENTS :- Mitochondria is observed to have the capability to move in cells, carrying ATP when required and may be located in particular cell region. Animal cells show less movement than plant cells.

MORPHOLOGY :—

1) In light microscopy, mitochondria appear as rod shaped filamentous or granular structures.
In spermatozoa and oocytes, these are seen as granules, while in lipid cells they appear as club shaped structures.
2) Depending on cell function, structure may change.
No is also variable as it's size.

BIOPHYSICAL PERSPECTIVE

① Mitochondria is a 2 membrane structures. Both the membrane has unit membrane structure. The outer and inner membrane is 60-70Å apart. Outer membrane is pitted and the pits are 2·5-3μ in diameter. They are spaced rather irregularly.

② The space between the two membrane is called as perimitochondrial space. It is 60-80Å wide and is filled with fluid.

③ The space enclosed by the inner membrane is called as inner chamber or inner membrane space.

④ Inner membrane space has matrix containing granules, 300-500Å mitochondrial DNA (m-DNA) and ribosomes (70S).

⑤ 2-6 circular DNA has been identified (De Robertis, 1987 says only one) DNA molecule/es may be present in the matrix or attached to the membrane.

⑥ Enzymes for Kreb's cycle is also present in the matrix.

side of the inner membrane facing the matrix is called <u>m-side</u> or the maturing side. The side facing the outer membrane is called <u>Cytosol or c-side</u>

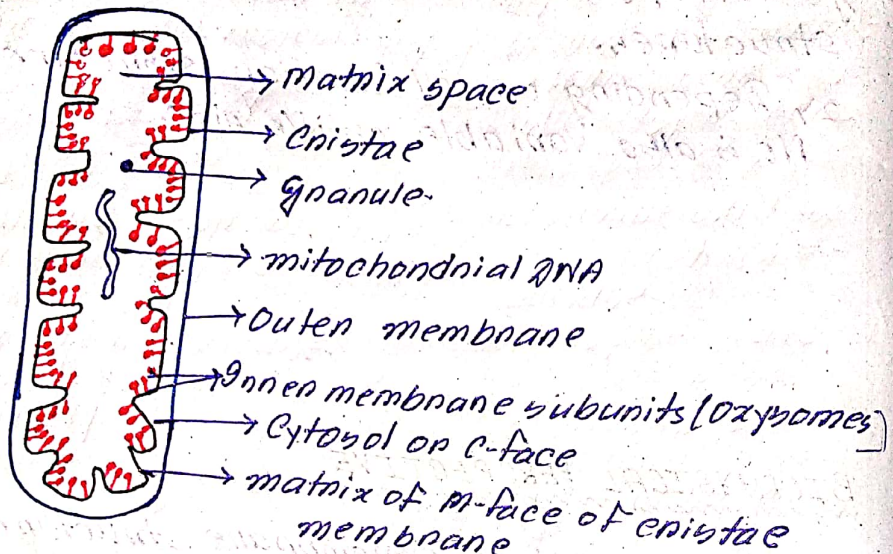


Fig:- MITOCHONDRION (Sectional View)

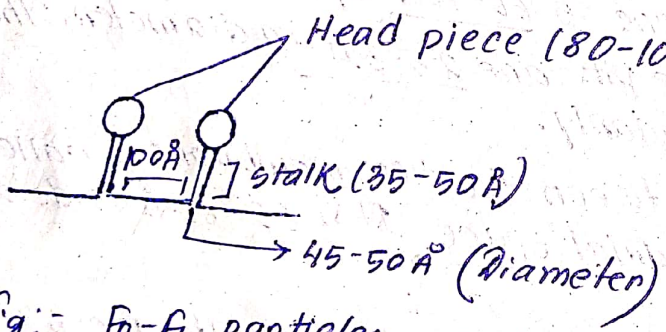


Fig:- F0-F1 particles.

(Feinandzen - Monan Particles)

ULTRA-STRUCTURE :-

CRISTAE =>

① The inner membrane is thrown called cristae mitochondria into the

② The cavity between the cristae is called the inter-cristal space and is continuous with the inner membrane space.

③ The cristae has small particles of 70-100 Å. They are attached to the membrane by a stalk of 35-50 Å. These particles are regularly placed at a distance of 100 Å.

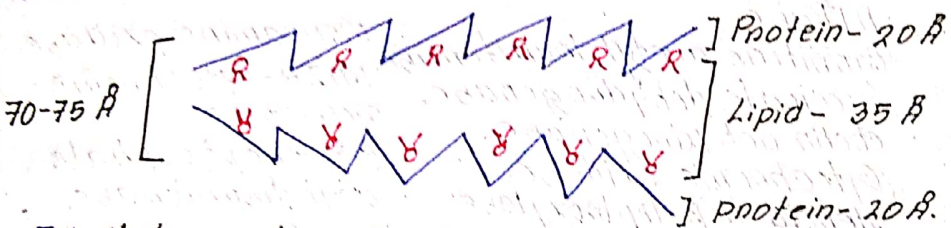


Fig:- Unit membrane structure of mitochondria.

MITOCHONARION PARTICLES:-

ELEMENTARY PARTICLES :- This may be about 10^4-10^5 in number. They are called F-particles or inner membrane particles.

REMARK :- These particles were previously thought of containing the enzymes for electron transport system and hence named as electron transport subunits. But later from the works of Hackens (1969) (1969) it was known to represent a special ATPase. on ATP synthatase. They are involved in process of oxidation or phosphorylation. The study included the following.

The head piece → ATPase proper.
The stalk – F_5 & F_6.
Base piece(F_0) → protein channel.

VIII COMPARISON BETWEEN THE PROPERTIES OF INNER AND OUTER MEMBRANE

		INNER MEMBRANE	OUTER MEMBRANE
1)	Lipids	Lessen amount of phospho lipid & cholesknol. Diphosphatidy Glycenol. a predominant component.	mone phospholipid & cholestenol present Lecithin is a pre-dominant component.
2)	Proteim	60% of total protein in - mitochondria. Protein ranging in thein mol. weight 10,000 - 90,000 Dalton.	Only about 10% present contaim 14 different proteim whose mol. weight ranges from 12,000 - 20,000 Dalton.
3)	Enzymes	ATPase. Cannitine acetyl tramferase Succinate dehydrogenase. cholin dehydrogenase. Cytochnome oxidase. steroid 11-B hydroxylase. 3-hydroxy butenate dehydro genase.	Monoamine oxidase. NADH - Cytochnome - reductase Glycenophosphate acyl tramferase. Hexokinase-2 cholin phosphotramferase. Acyl-co-synthase.
4)	SIALIC ACID	Less amount.	4 to 5 timen than inner membrane. It is associated with - glycoprotein/glycolipid.
5)	ION TRANSPORT	contain components such as ATP, ADP, phosphate di, tri carboxylate, glutanate etc.	No such component present.
6)	DIFFUSION	Substances less than 100 Dalton can pass.	Substancen up to 10,000 Dalton can pass

MITOCHONDRIAL DNA (m-DNA)

It was Nass, Nass and Afzelius (1965) who first demonstrated the occurence of mitochondrial DNA.

PROPERTIES :-

m-DNA is a circular molecule in most higher animals but linear in several eukaryotes and plants. It has a circumference of 5 μm. The m-DNA containing regions of mitochondria are called NUCLEOIDS. Each mitochondria may have 2 or 3 or may be upto 6 nucleoids. In addition to normal m-DNA, monomers, double sized dimers have also been found.

Differences between m-DNA & nuclear DNA

	m-DNA	n-DNA
1Y	Rapid rate of renaturation.	1) Slower rate of renaturation.
2Y	Has a more homogeneous base composition.	2) Base composition is heterogeneous
3Y	m-DNA is usually circular. It may be open or twisted. No. of rings vary from 2 to 6.	3) n-DNA has a double helical structure with only 2-strands.
4Y	Melting temperature (Tm) different from that of n-DNA.	4) Melting temperature (Tm) different from that of m-DNA.

SYNTHESIS OF m-DNA: Isolated mitochondria can synthesize DNA (Wintersberger, 1966). The synthesis of m-DNA is somewhat independent from that of n-DNA. Replication of m-DNA in Neurospora is semi-conservative (Rich & Luck, 1966).

FUNCTION :- m-DNA contains the generation for the synthesis of mitochondria. The entire process is not carried by certain mitochondrial proteins and by nuclear-DNA

ORIGIN OF MITOCHONDRIA

There are three ... regarding the origin is —

1Y From various cell membranes.
2Y By Division of POLLY FORMED MITOCHONDRIA.
3Y DE NOVO ORIGIN.

1Y FROM VARIOUS CELL MEMBRANES :-

Robertson (1964) showed that in muscle cells, mitochondria is formed from the infolding of plasma membrane into which passes a projection from the adjacent part of a membrane. This would result in a double membrane vesicle. With the growth of cristae from the inner membrane, would give rise to mitochondria.

He has also observed the conversion of ER into mitochondria.

The idea of origin of mitochondria from the nuclear membrane has not be accepted.

Plasma Membrane
↓
Projection from Adjacent part of membrane.
↓
DOUBLE MEMBRANE VESCICLE
OR
MITOCHONDRIA
↓
INNER MEMBRANE FORMS CRISTAE

ILLUSTRATION FOR THE ORIGIN FROM PLASMALEMMA

E.R OF NERVE CELLS
↓
MITOCHONDRIA.

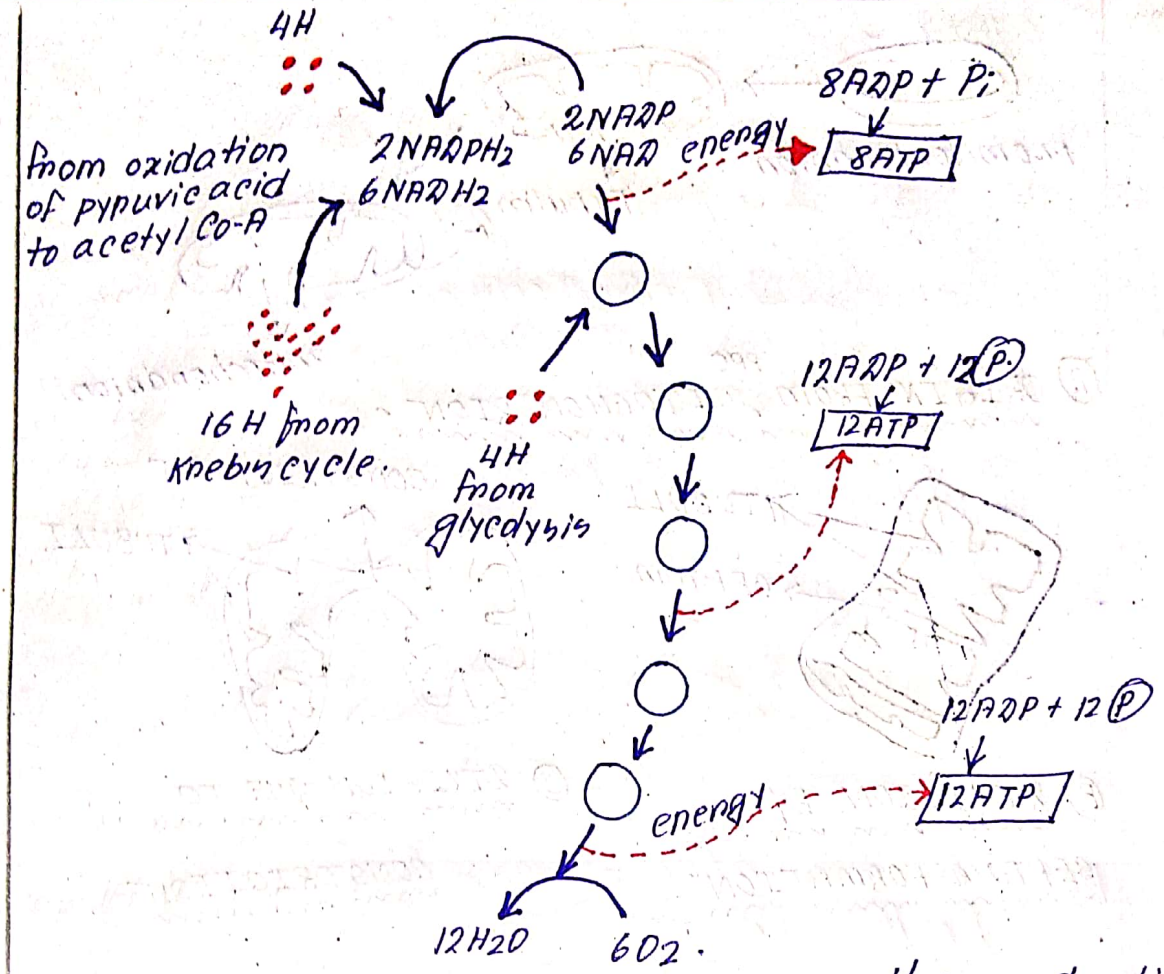
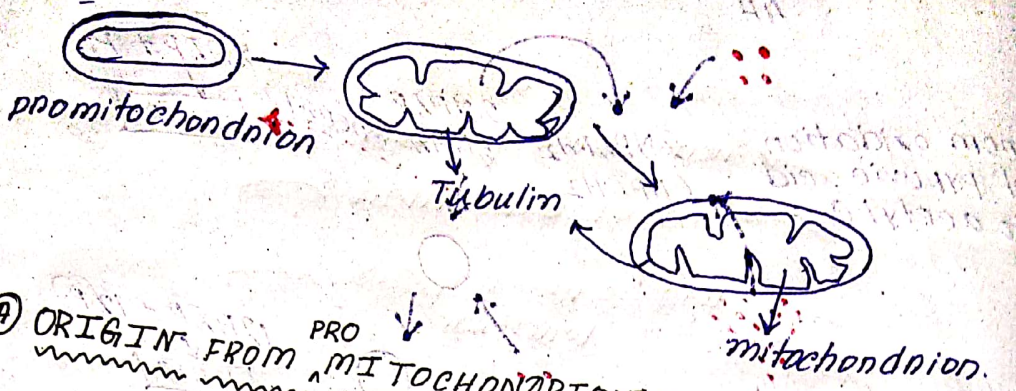
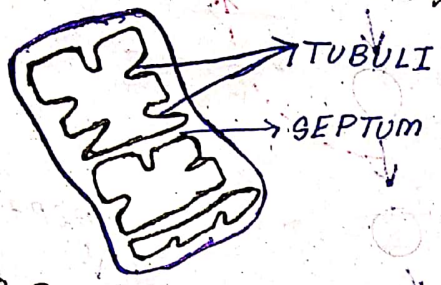


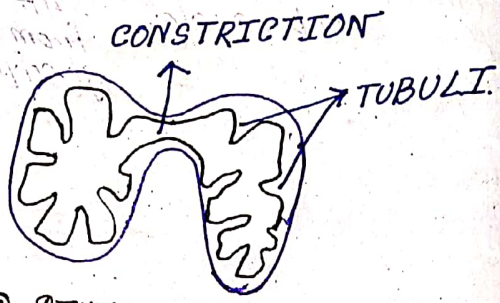
FIG:- A simplified representation showing the production of hydrogen in different stages of respiration and their subsequent use in the production of energy to be stored in the form of ATP - molecules.



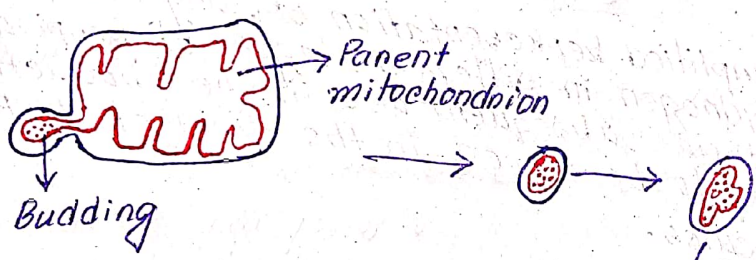
(A) ORIGIN FROM PRO MITOCHONDRION.



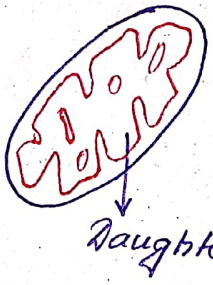
(B) DIVISION BY SEPTUM FORMATION



(C) DIVISION DUE TO CONSTRICTION



(D) ORIGIN THROUGH BUDDING



(A→D)

FOUR DIFFERENT METHODS OF ORIGIN OF MITOCHONDRIA

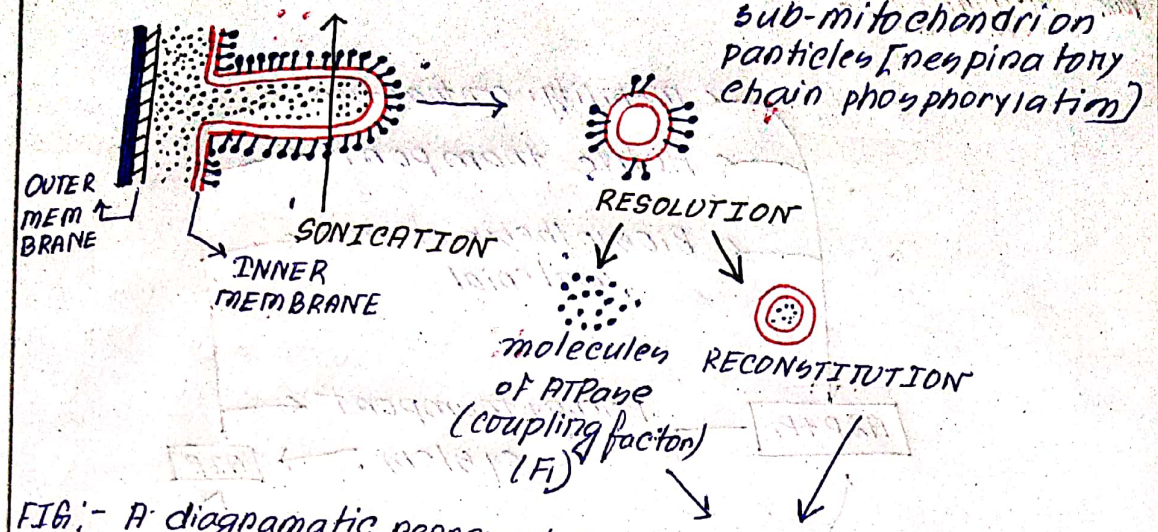


FIG:- A diagramatic representation showing the role of oxysomes in sub-mitochondrial particles.

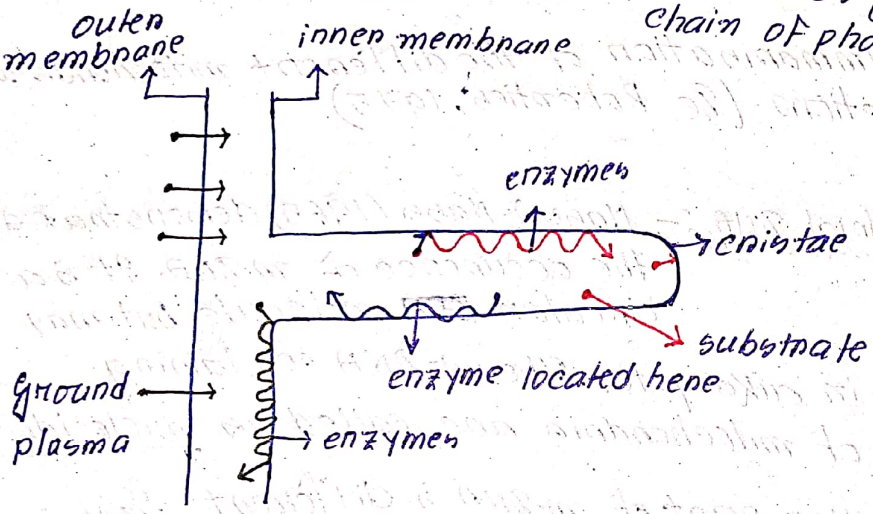


Fig:- A sectional view of cristae showing function of mitochondria (redrawn from Frey-Wyssling & Muhlethaler; Ultrastructural Plant Cytology)

VIII SUMMARY :-

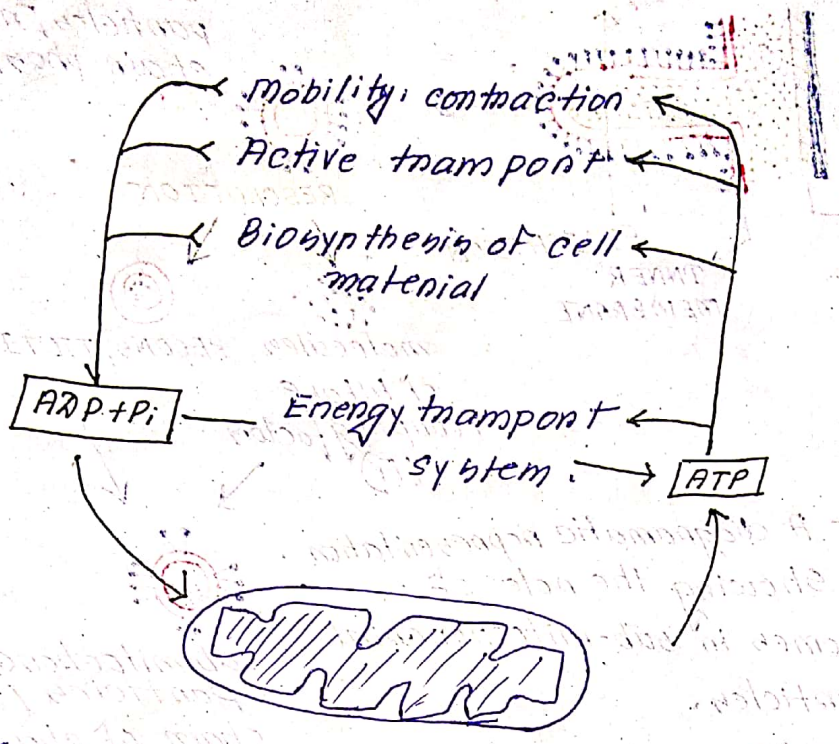


Fig:- Summarisation of the different mitochondrial functions. (De Robertis, 1975)

VIII Mitochondrial DNA :- Nass & Nass (1965) demonstrated the occurence of m-DNA. It is a circular molecule but may be linear in eukaryotes. The m-DNA containing regions of mitochondria are called as nucleoids.

The melting point of m-DNA is different from nuclear DNA. Its rate of renaturation is more rapid than the nuclear DNA. Its base composition is more homogeneous.

The synthesis of m-DNA is independent of the synthesis of nuclear-DNA.

The main function of mitochondrial ~~function~~ DNA is carry information about the activity of mitochondria.