Mitochondria

B.Sc. Part-1 Subs.

INTRODUCTION:

Although we do not know what is the first form of life on the earth where as we do not know the nature of equipment that started them on road to survival. Life was no more than an experiment of nature. In danger of being shifted out at anytime to perform two basic functions ~ reproduce themselves and produce energy. It is clear that all forms of life on our planet have basically the same systems for these two purposes. The power house which produces energy for the continuance of life is "mitochondria", the product of inexorable researches of cytologists have incorporated several main approaches by the turn of this century but could not reach at the peak until the marvels of electron microscope came into light.

HISTORY:

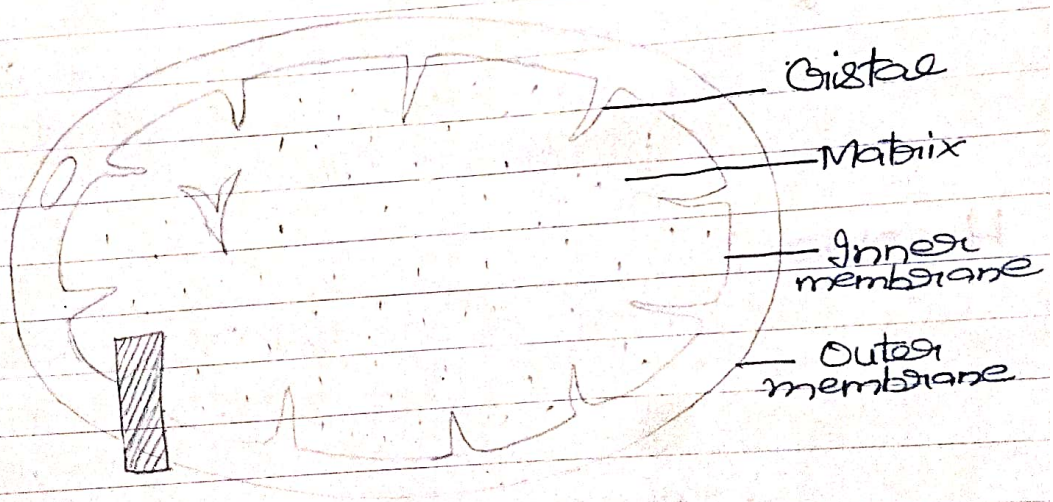
First of all ALTMAN (1894) described the presence of these particles in a cell and called them "bioplasts." Prior to him FLEMMING and KOLLIKER knew about them but their work remain hidden in the darkness untill BENDA (189 demonstrated the structures described by ALTMAN and FLEMMING called them mitochondria (Gr. Mit fibament, chondras - granule) BENDA demonstra the presence of MITOCHONDRIA in a living cell in 1900.

STRUCTURE:

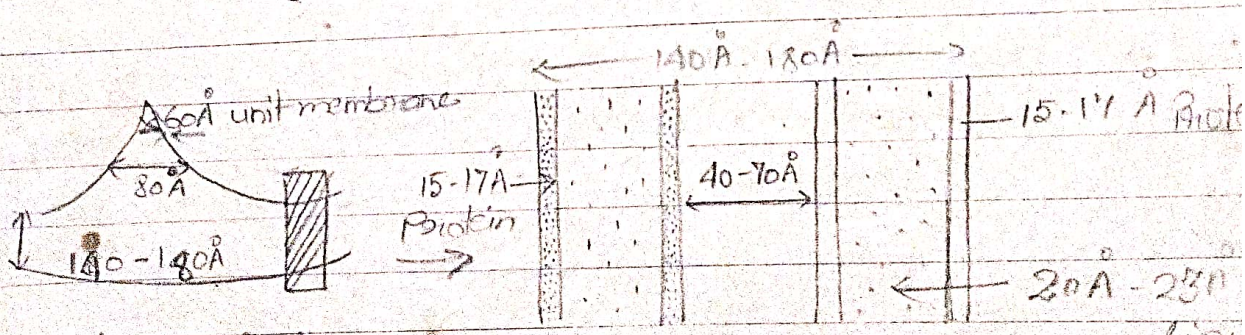
Structure can be studied under following heads:

OUTER LIMITING MEMBRANE:—

The membrane is double. Outer membrane is about 60 Å in thickness. Inner membrane is of same diameter and shows many foldings. The space between outer and inner membrane is 40-70 Å. These membranes consist of an outer and inner protein sub layers; outer and inner protein sublayers measure 15-17 Å and the middle lipid layer measures 20-23 Å.



(A) Mitochondria in cross-section.



Diameter of Area marked in (A)

Diameter of area marked in B.

MATRIX:

It is dense and granular forming many outgrowths as a result of infolding of inner membrane. These infoldings are called cristae. The arrangement of cristae is as follows:-

(I). They may be parallel to the long axis of mitochondria.

(II) Commonly they lie perpendicular to the long axis.

(III) These may be in the form of vesicles, usually forming a network of connecting chambers as in parathyroid gland cells and human W.B.C.

(IV) In certain spermatids these cristae are arranged concentrically in matrix.

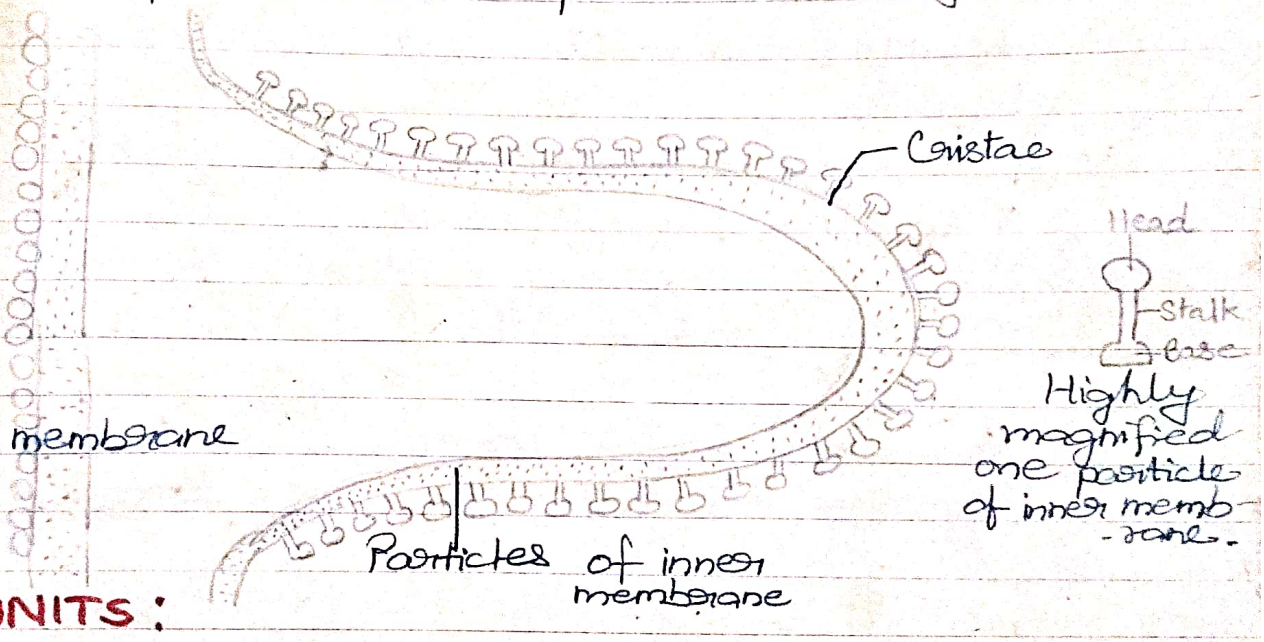
(V) In Amoeba many cristae become inter-lobed forming villi.

The greater and longer the cristae the stronger its capacity to carry on oxidative reaction.

subunits
the elect

ASSOCIATED PARTICLES:

The surface of both the mem... are very much sprinkled with thousands of smaller particles (80-100 Å). These particles are attached to the inner surface of the inner membrane and the outer surface of the outer membrane. These particles are the elementary units that carry out the chemical activities of the mitochondria. It has further been suggested that each particles of the inner membrane is made up of spherical head piece, a base piece and a cylinder stalk.



SUB UNITS:

Parsons (1963) has described the presence of sub units on the surface of cristae in the rat tissue cells and in the ~~rat tissue cells and~~ pancreatic cells. Each sub units comprise a stem 30-35 Å in diameter and 40-50 Å long and a round head 75-80 Å in diameter. These subunits are closely packed on the surface of the cristae with an intercentral distance of 100 Å. These

subunits represent the enzyme molecules of the electron transport system.

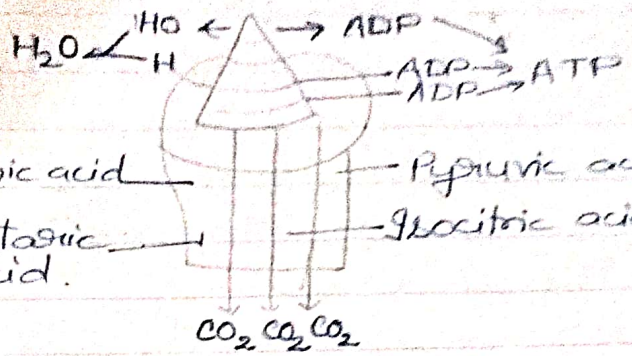


fig: A Mitochondrial Sub unit

Thus there are two cavities in a mitochondrian — the one occupied by mitochondrial matrix and the other between two membranes of the wrapper.

CHEMICAL COMPOSITION:

Each membrane is composed of phospholipids and proteins. Mitochondria has a lower refractive index which supports the theory of their lipoidal nature. According to BOURNE (1942) they posses a lipoidal cortex surrounding core of protein and it is claimed that they contain vitamin A, vitamin C, Proteolytic enzymes and other substances.

According to BOURNE (1944) mitochondria posses;—

(i) A surface film which is mosaic.
(ii) Protein and fatty acid substance contain some lacithin and cephalin.
(iii) Cortex containing fatty material, Vit. A, glutathio and proteolytic enzymes.

According to BENSLEY (1947) vitamin B

complex is also present.

Examination of isolated mitochondria under electron microscope by CLAUDE and FULLEN (1948) SCHMIDT and others show that the mitochondria contains small bodies having greater electron density than the rest of mitochondria According to BENSELY mitochondria of hepatic cells of some animals contain -

(i) Protein and unrecognised substances - 65%.
(ii) Glycerides - 29%.
(iii) Lecithine - 40%.
(iv) Cholesterol - 2%.

According to CLAUDE mitochondria of liver cells contain principally the proteins and lipids. Lipids represent only 25%. 70% - 80% of lipids is phospholipids besides these are following chemical present

(i) Ribonucleic acid (R.N.A) - 19%.
(ii) Iron — 1·2%.
(iii) Copper — 0·02 to 0·35%.
(iv) Various enzymes demonstrated by histochemical methods i.e. proteolytic enzymes, cytochrome oxidase and succinic dehydrogenase co-enzymes.
(v) Vitamin A, Vitamin B complex and Vitamin C.

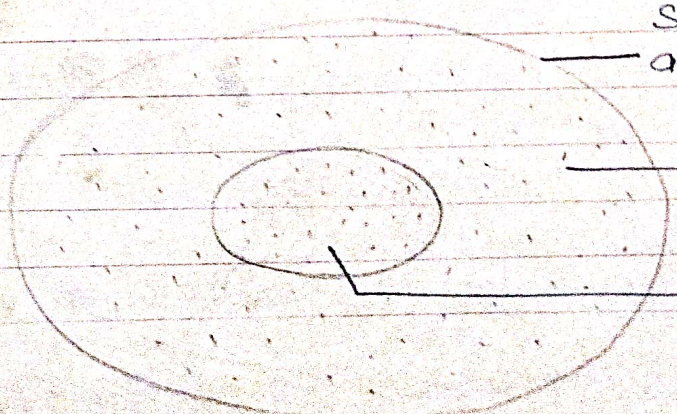


fig. showing Chemical composition.

(1) FUNCTION OF MITOCHONDRIA:

According to KINGSBURY (1919), J. CAVENGENE (1935) and others, mitochondria is the centre of cell respiration. They passes considerable oxidising and reducing power. Discoveries of CLAUDE (1943-44) and HOGBOM (1946-47) confirmed that mitochondria are chief centre of aerobic respiration of cells.

Mitochondria is the actual site of the cell where carbohydrate, fat and protein are completely oxidised into CO_2 and H_2O. In the carbohydrate metabolism after glycolysis the pyruvic acid is produced. This pyruvic acid enters into mitochondria for its complete oxidation into CO_2 and water by the krebs cycle. Before entering into the krebs cycle there is oxidative decarboxylation of pyruvic acid to acetyl coenzyme A.

After the digestion of fat, the end product is glycerol and fatty acid which diffuse into blood of that particular system. After reaching into the cell, glycerol is phosphorylated and converted into glyceraldehyde 3 phosphate. The glyceraldehyde 3 phosphate after passing through the pathways of glycolysis, oxidative decarboxylation and krebs cycle is ultimately oxidised into CO_2 and H_2O with the liberation of various molecules of A.T.P. The fatty acids are oxidised by β-oxidation and re-enter into the krebs cycle for its complete combustion and

liberation of energy.

After the digestion of protein the amino acids are first de-aminated into keto-acids by oxidase enzyme.

$$\text{Amino acids} + CO \xrightarrow{[O]} \alpha\text{-amino acids}$$

$$\alpha\text{-amino acids} + H_2O \xrightarrow{\text{oxidase enzyme}} \text{keto acids} + NH_3$$

The keto acids are converted into oxalo-acetic acid and α-ketoglutaric acid. Both of these enter into the krebs cycle for its complete oxidation and liberation of energy.

In this way mitochondria can be considered as the "power-house" of the cell.

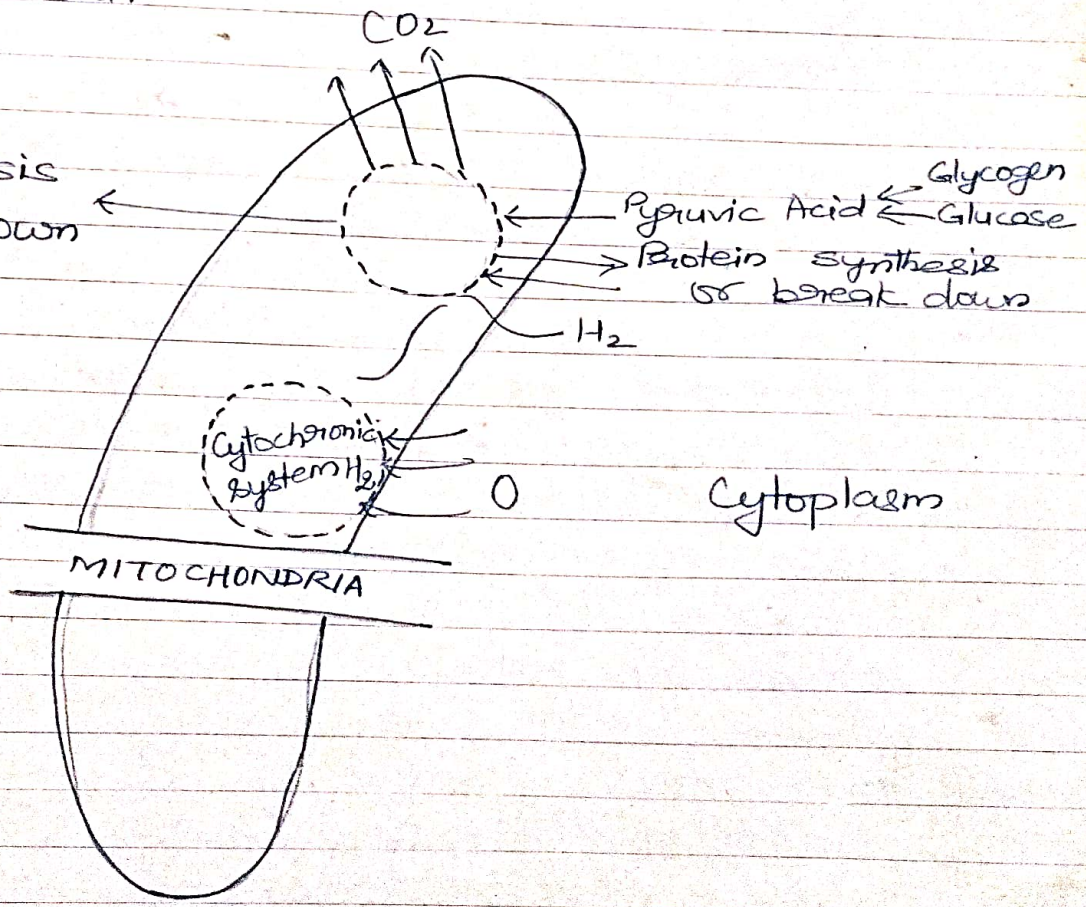


Diagram showing aerobic metabolism of carbo-hydrate between mitochondria are concerned.

According to HOWING mitochondria are concerned with enzymatic activity and with the certain formed products.

In cytochemistry HOWING believed that mitochondria are concerned with the production of digestive enzymes and in general mitochondria are responsible for the production of zymogen granules.

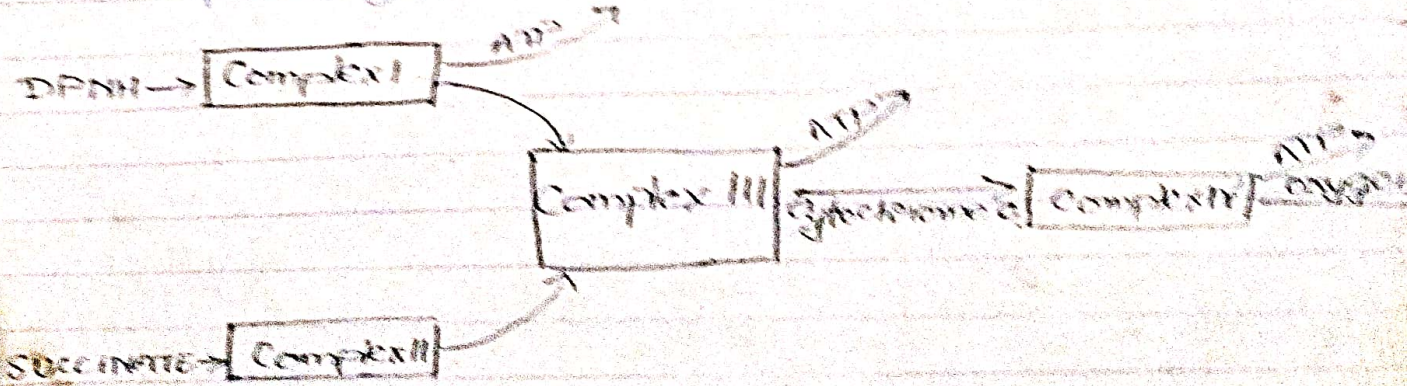
(ii) LEVI and CHEVREMONT believe that myofibrils have mitochondrial origin.

(iii) HITTON suggested by studying the mitochondria of transgenes that they are associated with fat metabolism.

It was supported by BENSLEY (1947). According to BENSLEY mitochondria really represents a reservoir, store metabolic material for the cells.

(iv) In oogenesis mitochondria are responsible for the production of albumines or protein yolk.

(v) In spermatogenesis mitochondria forms the mitochondrial sheath of the middle piece of the spermatozoon.



Electron transmission through a series of complexes inside the mitochondrion.