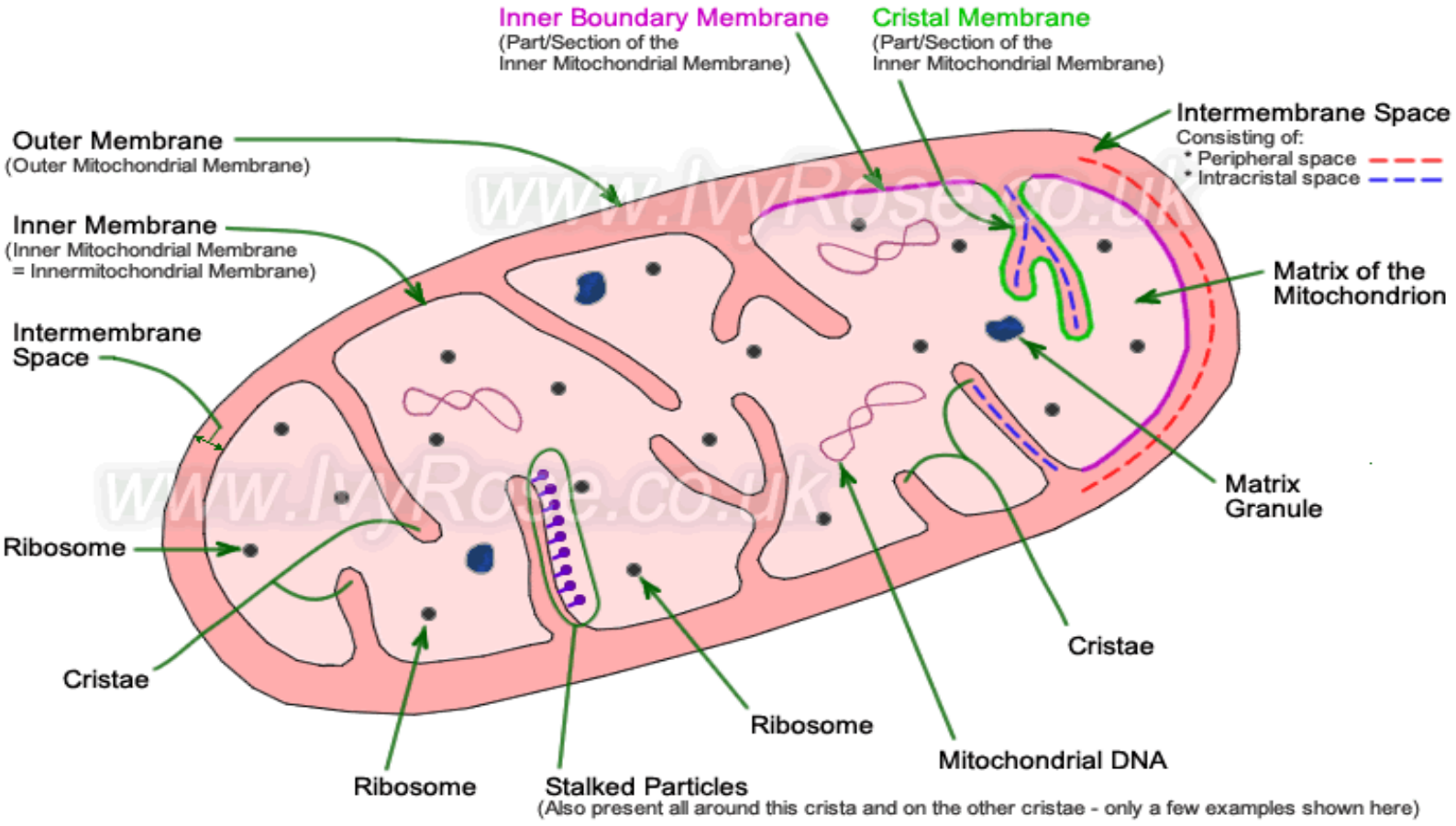
MITOCHONDRIA

- Mitochondria are known as the powerhouses of the cell. They are organelles that act like a digestive system

MITOCHONDRIA



ORIGIN

Two Hypotheses

- **Endosymbiotic**

Mitochondria descended specialized bacteria and survived by prokaryotes and other cell type

- **Autogenous**

Originate by splitting of DNA from nucleus in eukaryotes

SIZE

The size of mitochondria also varies. The size of cell also depends on the functional stage of the cell.

- In majority of the cells, width is relatively constant, about 0.5µ but the length varies and,sometimes, reaches a maximum of 7µ
- Very thin mitochondria, about 0.2µ, or thick rods 2µ are also seen.

MOTION OF MITOCHONDRIA

In the living cell, the three most common mitochondrial movements were:

- Small oscillatory movements
- larger movements
- Whole transit movements of single mitochondrial

Shape

The shape is variable but is characteristic for a cell or tissue type, this too is dependable upon environment or physiological conditions.

Distribution

Ordinarily mitochondria are evenly distributed in the cytoplasm. They may, however, be localized in certain regions.

- In proximal convoluted tubules of the kidney
- In skeletal muscles
- In cardiac muscle
- In many sperms
- In leucocytes

Number

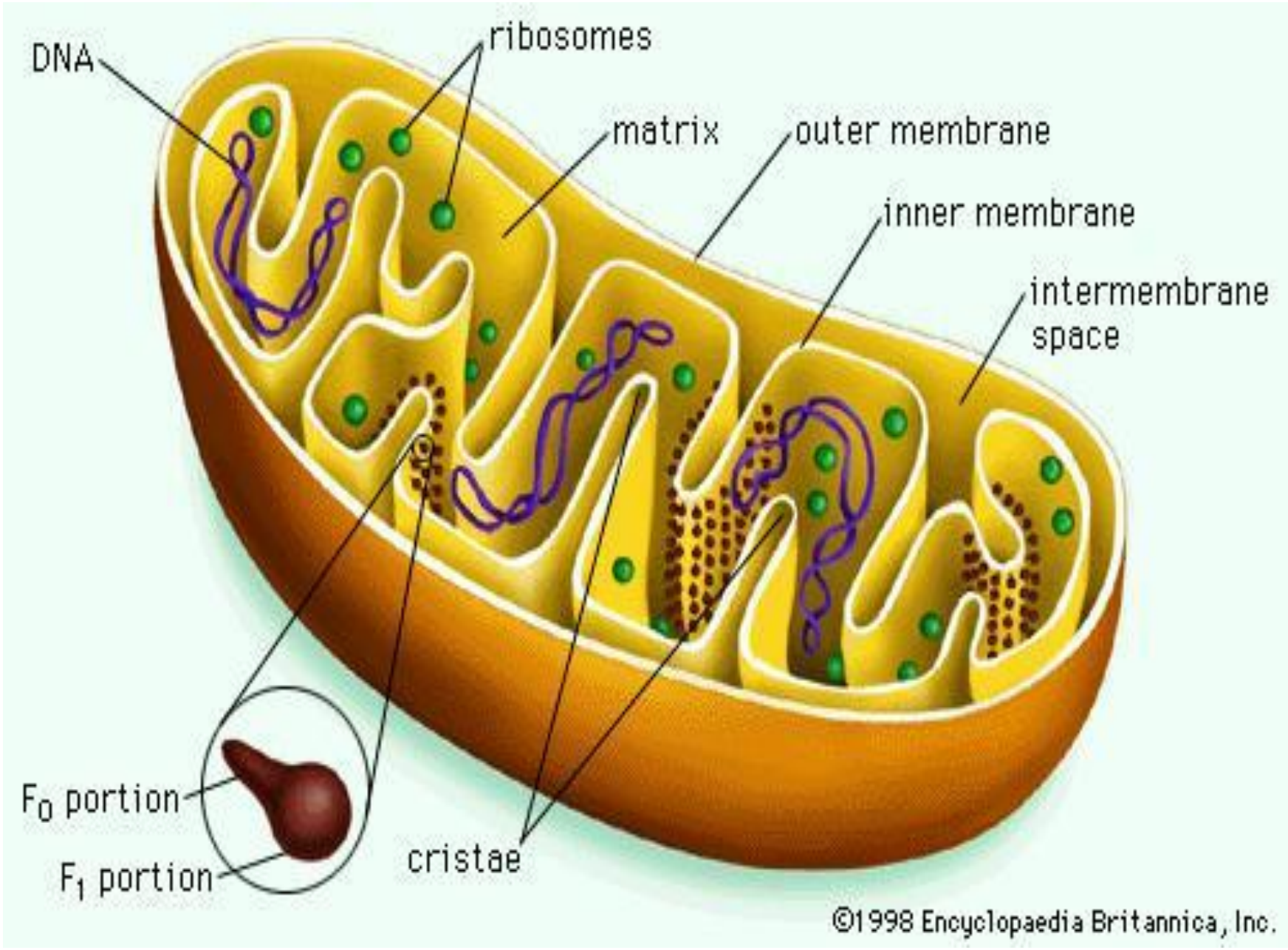
Mitochondria are found in the cytoplasm of all aerobically respiring cells

Thus cells with high metabolic activity have a high number of mitochondria, while those with low metabolic activity have a lower number

- Large sea urchin eggs have 13,000-14,000
- while renal tubules have 300-400
- In the sperm there are as few as 20- 24 mitochondria
- while in some oocytes there are about 300,000

Structure of Mitochondria

- The outer mitochondrial membrane
- The intermembrane space
- The inner mitochondrial membrane
- The cristae space
- The matrix
- F1 particle


DNA
ribosomes
matrix
outer membrane
inner membrane
intermembrane space
F_0 portion
F_1 portion
cristae
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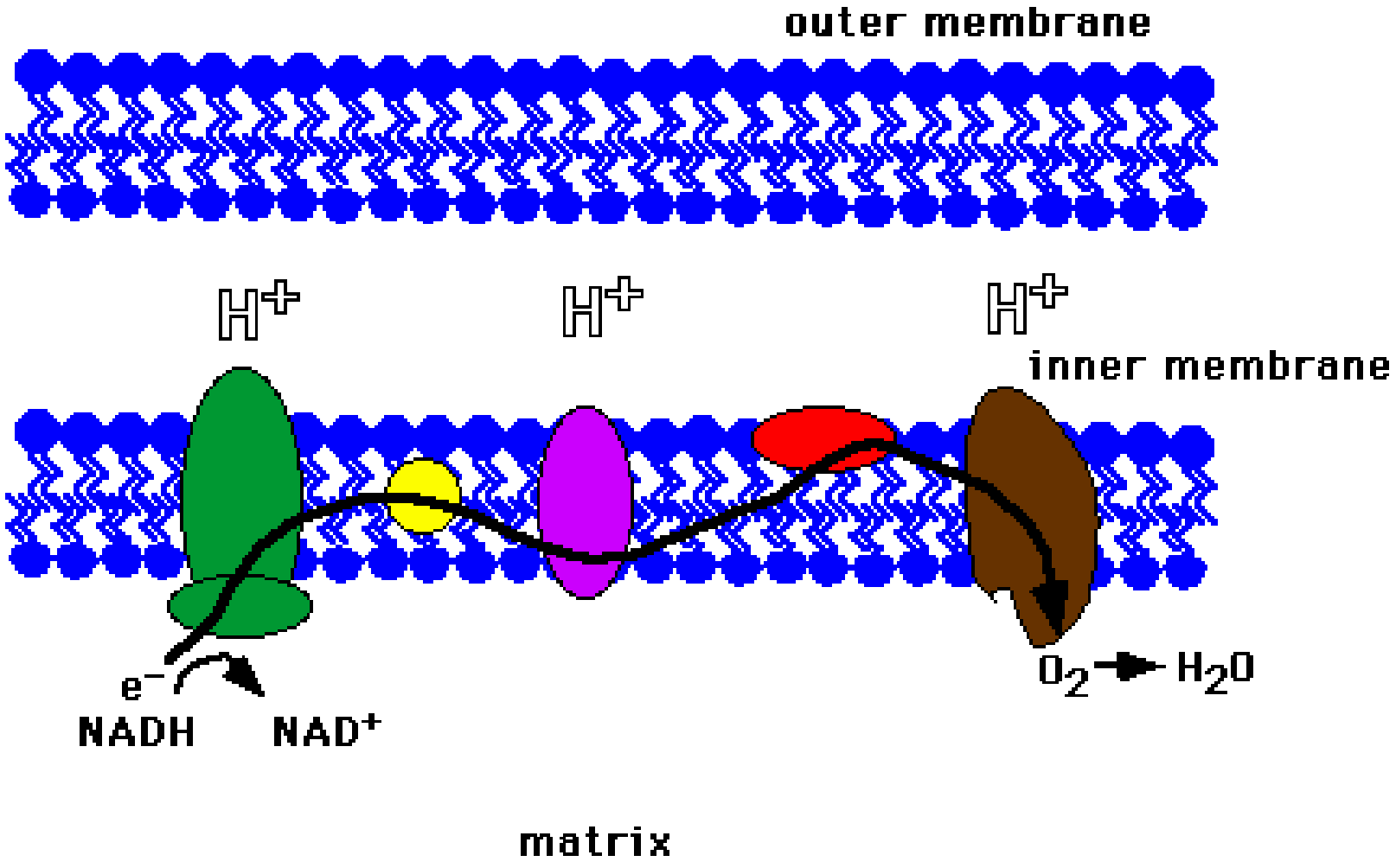
Outer membrane

- The outer membrane covers the organelle and it is smooth like a skin.
- The outer membrane is a relatively simple phospholipid bilayer, containing protein structures called prions
- It is permeable to molecules of about 10 kilo Daltons or less (the size of the smallest proteins)
- Ions, nutrient molecules, ATP, ADP, etc. can pass through the outer membrane with ease.

Inner membrane

The inner mitochondrial membrane is more complex than outer membrane contains proteins with different types of functions:

- Those that perform the redox reactions of oxidative phosphorylation
- ATP synthase, which generates ATP in the matrix
- Specific transport proteins that regulate metabolite passage into and out of the matrix
- The inner membrane is freely permeable only to oxygen, carbon dioxide, and water.


outer membrane
H+
H+
H+
inner membrane
e−
NADH
NAD+
O2
H2O
matrix

The components of both membranes

- Lipid -- cholesterol, phospholipid and sphingolipid
- Proteins
- Carbohydrate -- as glycoprotein

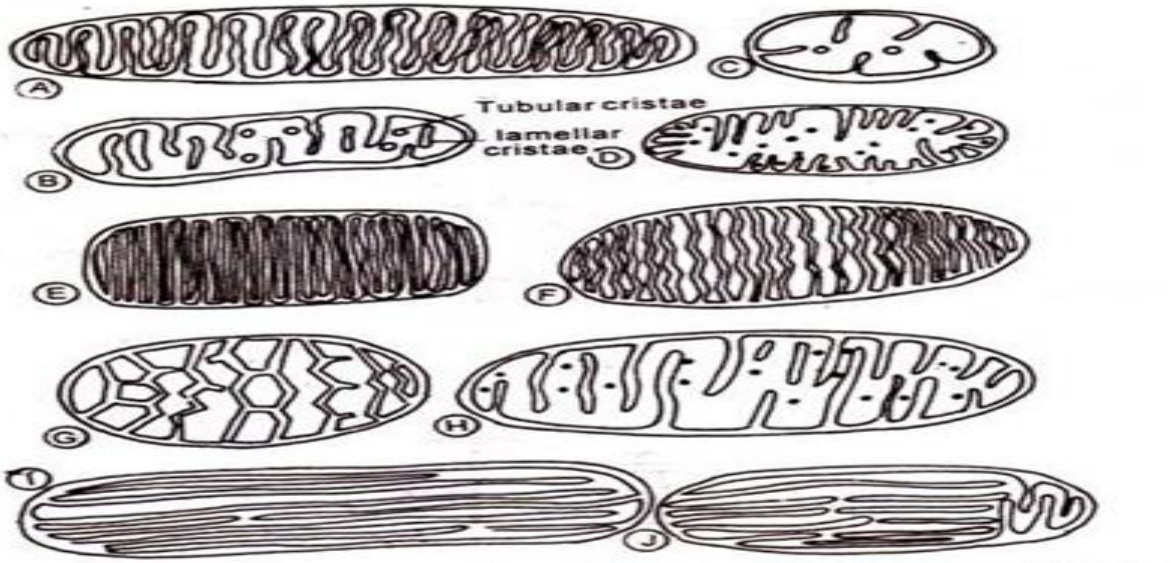
Structural & Chemical Differences in Both Membrane

- The outer membrane has 40% lipid content while inner membrane contain only 20%
- The outer membrane contains more cholesterol and higher in phosphatidyl inositol
- Lipid/protein ratio in outer membrane is 0.8 while it is 0.3 in the inner membrane
- Outer membrane lack the elementary particle that are prominent in the inner membrane

Cristae

The inner membrane is thrown up into a series of folds, called mitochondrial cristae which project into the inner chamber.

- The cristae with their folds, the cristae increase the total surface area of the inner membrane
- The quantity and shape of the cristae may vary



Structural variations in mitochondrial cristae. A Tubular cristae, *B* lamellar cristae, C. Cristae in salamander D. Plate like cristae, E. parallel cristae, F. cristae with sharp annulation, G. honey combs cristae, H. Usual cristae, I. Longitudinal cristae, J. Transverse and longitudinal cristae.

Cristae

The cristae create two sections in the mitochondrion

- **The intermembrane space**
- **The matrix**

The intermembrane space

This lies between the outer and inner membranes.

- It has same concentration of small ions and sugar as in the cytosol
- It has an important role in the primary function of mitochondria, which is oxidative phosphorylation

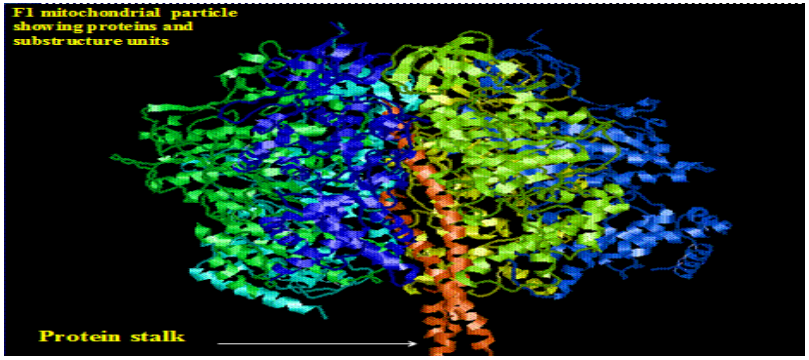
The matrix

- This is the inner space enclosed by the inner member.
- Mitochondrial matrix contains: 65 to 70% proteins; 25 to 30% lipids; 0.5% RNA and circular DNA molecule
- The matrix contains the enzymes that are responsible for the citric acid cycle reactions.

Mitochondrial Particles

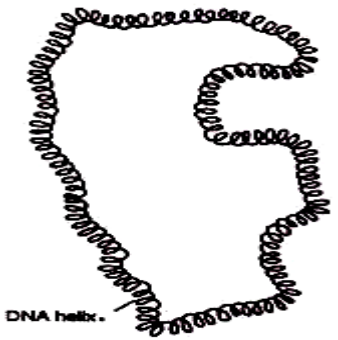
The inner surface of the inner membrane were supposed to be covered with thousands of small particles FI particles ETP or electron transport particles.

- There may be as many as 10,000 to 100,000 particles per mitochondrion
- They have complicated proteins and a mobile stalk essential to their energy producing function.
- They have special ATPase that involved in oxidation and phosphorylation



Mitochondrial DNA

- Mitochondrial DNA is called as mt DNA which is double stranded circular DNA located in the matrix.
- Each mitochondrion may contain one or more DNA molecules depending on its size
- Mitochondrial DNA differs from nuclear DNA in several respects. The guanine and cytocine content is higher in mitochondrial DNA . The amount of genetic information carried by mitochondrial DNA is not sufficient to provide specifications for all the proteins and enzymes



Mitochondrial DNA.

Mitochondrial RNA (mt RNA)

The amount of mt-RNA is about 10 to 20 times that of mt-DNA. All sorts of RNA have been identified in mitochondria.

Mitochondrial Ribosomes

Mitochondria appear to contain ribosomes which are smaller in diameter than cytoplasmic ribosomes

Mitochondrial Enzymes

Outer Membrane Enzyme

- Monoamine oxidase

It catalyze the oxidative deamination of monoamines. Oxygen is used to remove an amine group from a molecule, resulting in the corresponding aldehyde and ammonia.

- Kynurenine hydroxylase

It catalyzes the chemical reaction belongs to the family of oxidoreductases and play the role of reduction of oxygen.

L-kynurenine + NADPH + H^+ + O_2 $\leftrightarrow$ 3-hydroxy-L-kynurenine + $NADP^+$ + H_2O

- Fatty acid CoA ligase

It is an enzyme of the ligase family that activates the breakdown of complex fatty acids. Long chain fatty acyl-CoA synthetase catalyzes the formation of fatty acyl-CoA

Inter membrane space enzyme

- Adenylate kinase

It catalyzes the rephosphorylation of AMP to ADP

- Nucleoside diphosphokinase

It is a enzymes that catalyze the exchange of terminal phosphate between different nucleoside diphosphates (NDP) and triphosphates (NTP) in a reversible manner to produce nucleotide triphosphates.

Matrix enzyme

- Malate and isocitrate dehydrogenase

Malate dehydrogenase is an enzyme that reversibly catalyzes the oxidation of malate to oxaloacetate

Isocitrate dehydrogenase is an enzyme that catalyzes the oxidative decarboxylation of isocitrate, producing alpha-ketoglutarate (α-ketoglutarate) and CO2

- Fumarate and aconitase

Fumarate is an enzyme that catalyzes the reversible hydration/dehydration of fumarate to malate

Aconitase is an enzyme that catalyses the isomerization of citrate to isocitrate

- Citrate synthetase

It responsible for catalyzing the first reaction of the citric acid cycle the condensation of acetyl-CoA and oxaloacetate to form citrate.

- Alpha keto acid dehydrogenase

It comprising pyruvate dehydrogenase and alpha-ketoglutarate dehydrogenase, key enzymes that function in the Krebs cycle

- Beta oxidation enzymes

beta-oxidation is the catabolic process by which fatty acid molecules are broken down to generate acetyl-CoA, which enters the citric acid cycle, and NADH and FADH2, which are co-enzymes used in the electron transport chain.