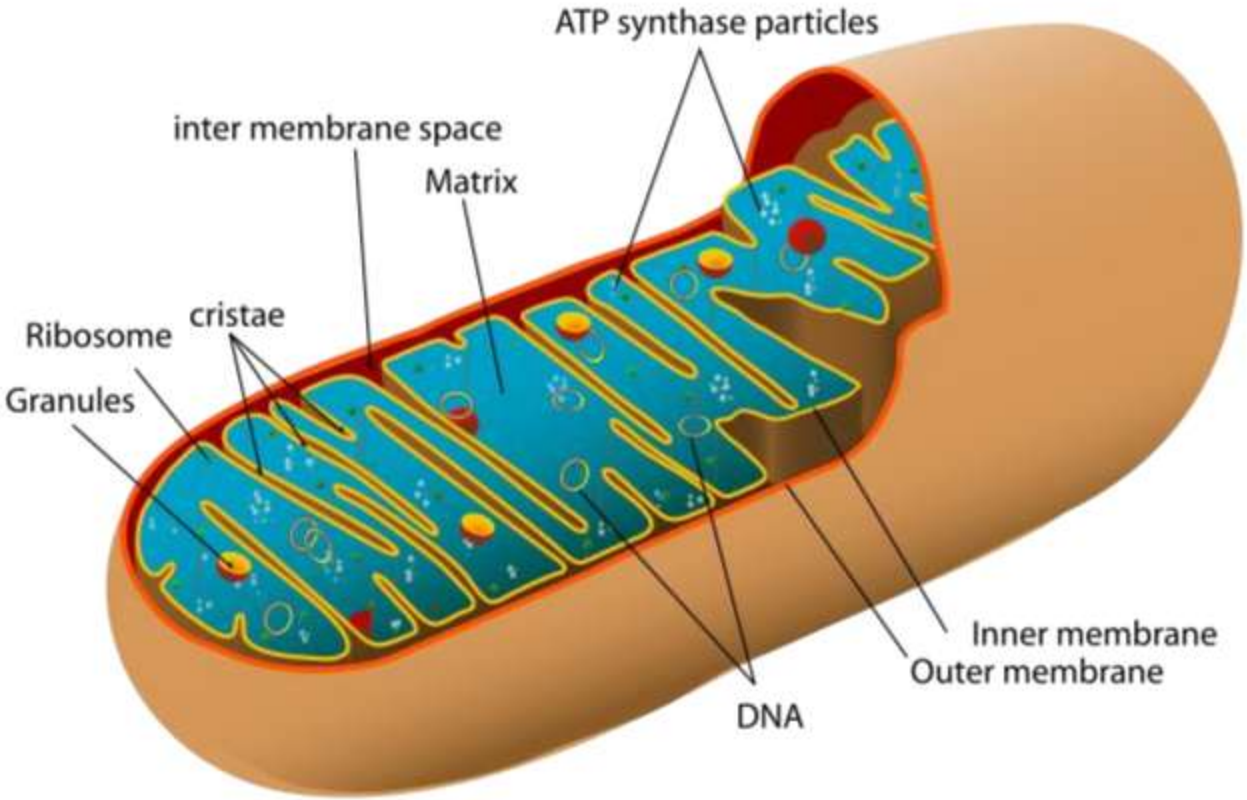
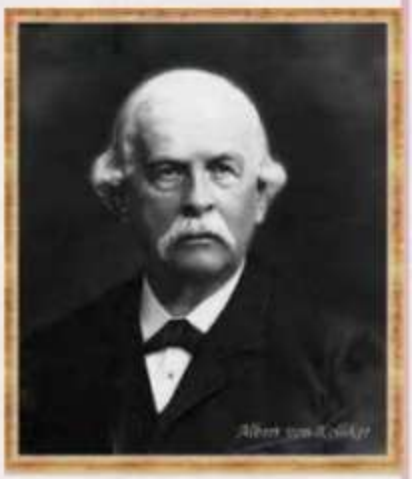
MITOCHONDRIA



INTRODUCTION

- Mitochondria is a double membrane bound organelle found in cytoplasm of eukaryotic cells.
- Mito – thread, chondrion – granule like.
- First observed by Richard Altman (1894)
- Term mitochondria was coined by Carl Benda (1898)
- They produce enzymes for the metabolic conversion of food to energy



Richard Altman

Carl Benda

POWERHOUSE OF THE CELL

Mitochondria are responsible for the conversion of nutrients into energy–yielding molecule ATP to fuel the cells activities. The function known as **aerobic respiration** is the reason mitochondria are frequently referred to as the powerhouse of the cell.

Aerobic respiration involves:

Glycolysis

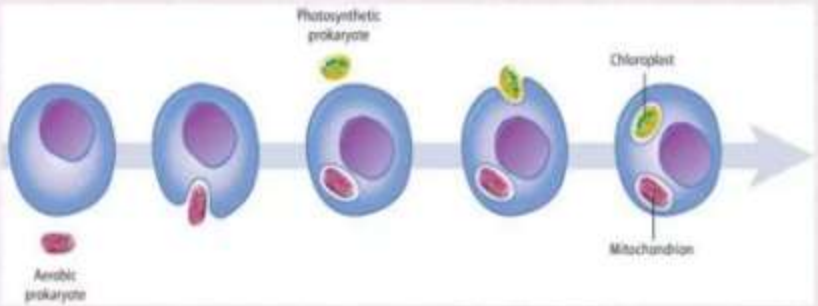
Krebs cycle

Electron

ORIGIN OF MITOCHONDRIA

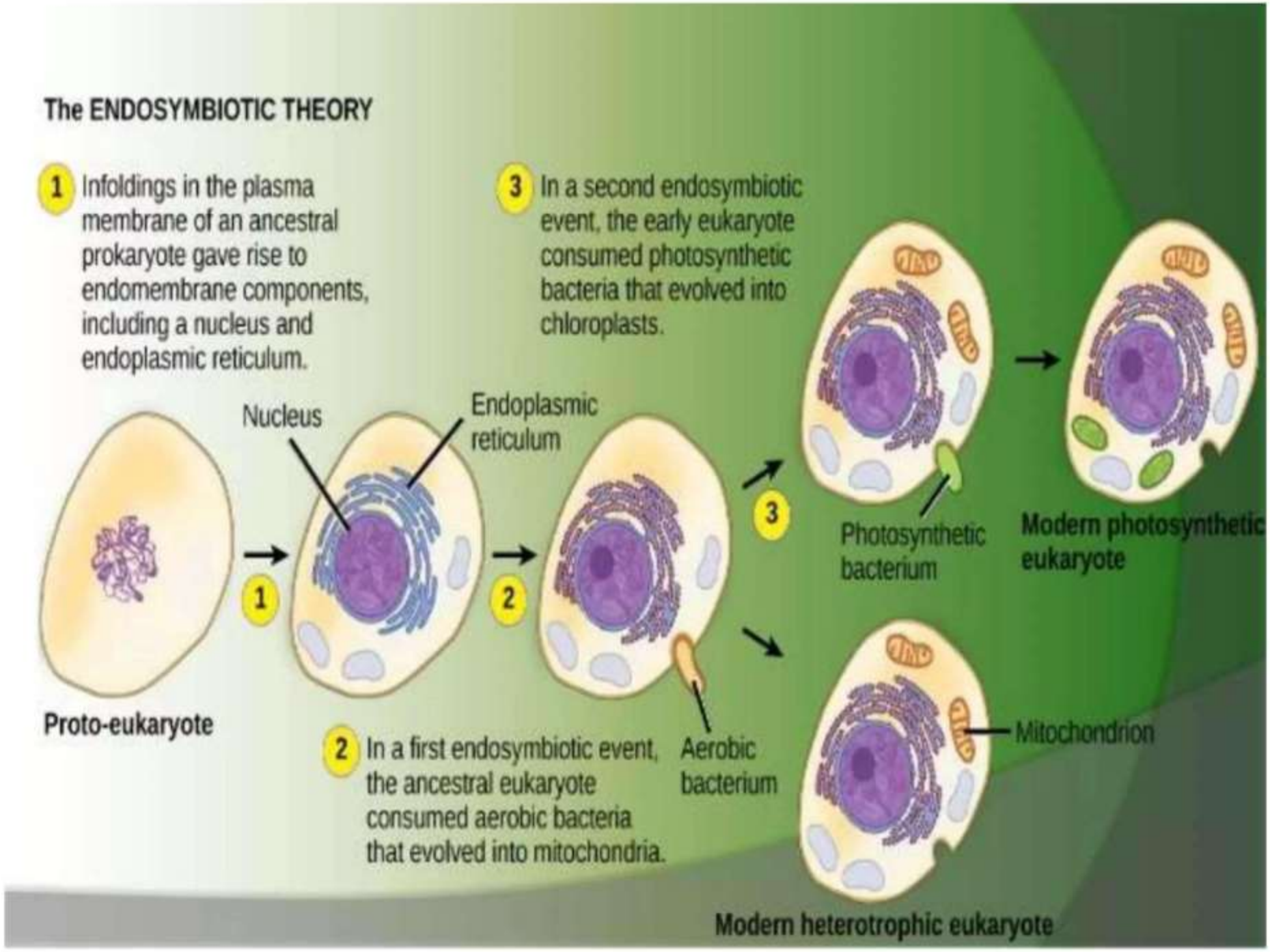
- Mitochondria are derived from bacteria by a process termed as **endosymbiosis.**

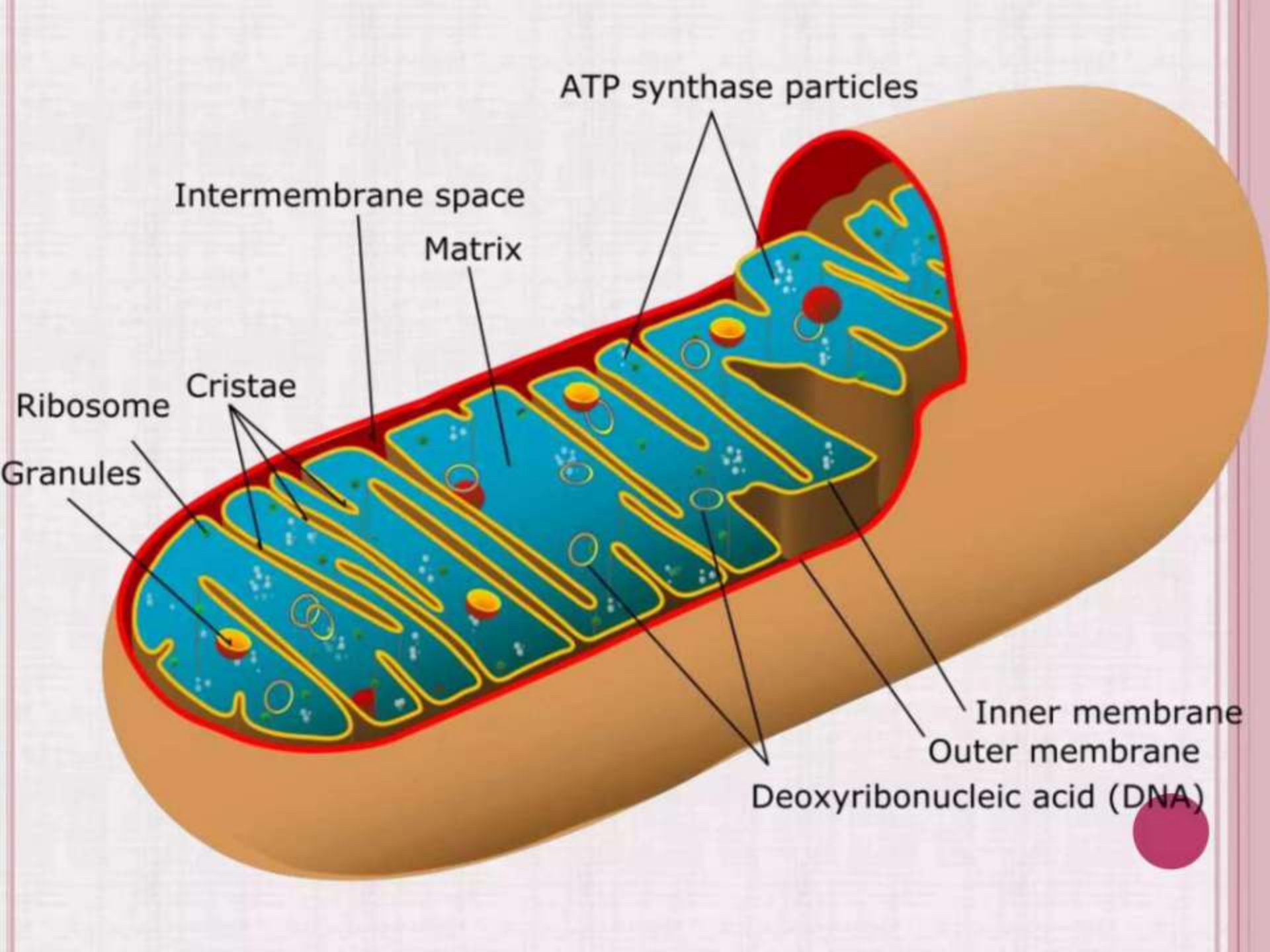
- Mitochondria arose about 2 billion years ago when a bacterium fused with an archael cell or established a symbiotic relationship with a primitive eukaryotic cell.



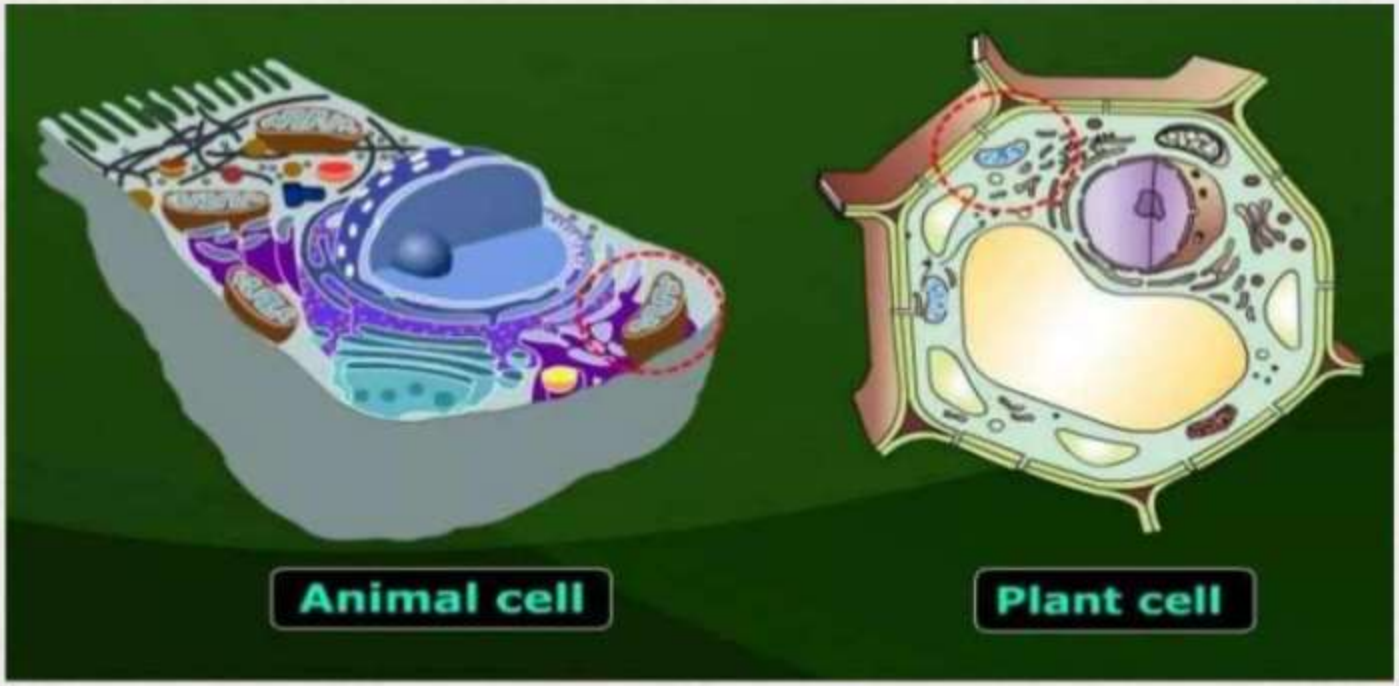
- The closest extant relatives of Bacteria that gave rise to mitochondria are **Rickettsia.**

- The first person to recognise mitochondria as descendents of endosymbiotic bacteria was **Ivan**

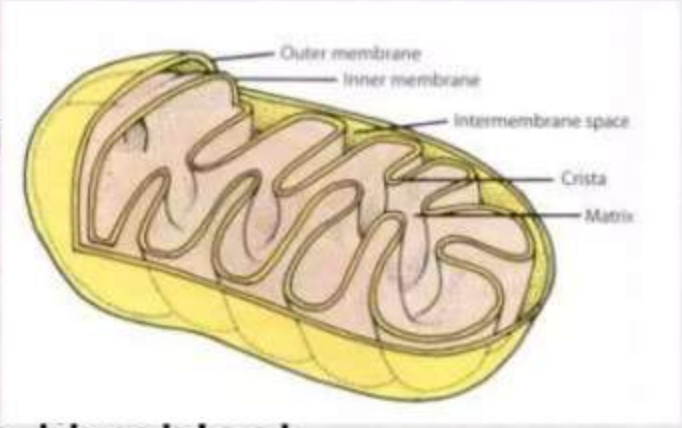

The ENDOSYMBIOTIC THEORY
1 Infoldings in the plasma membrane of an ancestral prokaryote gave rise to endomembrane components, including a nucleus and endoplasmic reticulum.
3 In a second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria that evolved into chloroplasts.
Nucleus
Endoplasmic reticulum
1
2
3
Photosynthetic bacterium
Modern photosynthetic eukaryote
Proto-eukaryote
2 In a first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria that evolved into mitochondria.
Aerobic bacterium
Mitochondrion
Modern heterotrophic eukaryote


ATP synthase particles
Intermembrane space
Matrix
Cristae
Ribosome
Granules
Inner membrane
Outer membrane
Deoxyribonucleic acid (DNA)

LOCATION OF MITOCHONDRIA



MORPHOLOGY

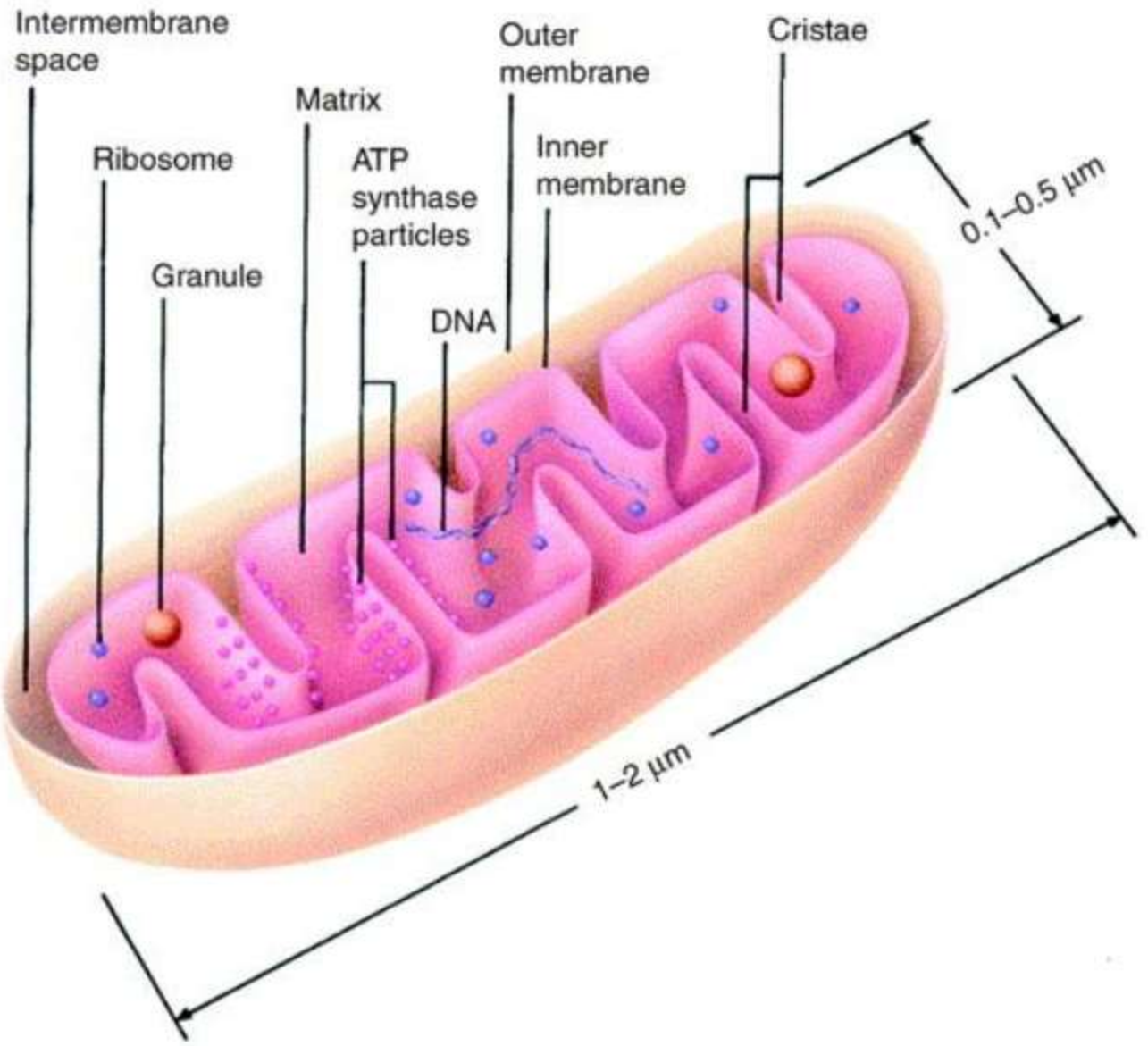


- **Size** 0.05 – 1.0 µm in
- **Length** 1 – 10 µm long
- **Shape** Bean shaped , in fibroblast it is elongated and thread like.
- **Number** Depends on type, size and functional state of cell.
  Eg : an average liver cell contain around 1500 mitochondria.

STRUCTURE

- **OUTER MEMBRANE**
- **INTERMEMBRANE SPACE**
- **INNER MEMBRANE**
- **CRISTAE**
- **MATRIX**

- The outer and inner membrane is composed of **phospholipid bilayers and proteins**. The two membranes have different properties.


Intermembrane space
Ribosome
Granule
Matrix
ATP synthase particles
DNA
Outer membrane
Inner membrane
Cristae
0.1–0.5 µm
1–2 µm
TiBS

OUTER MEMBRANE

- Simple phospholipid bilayer.
- It encloses the mitochondrian.
- Contain large number of integral protein structures called **porins**, which allows molecules to freely diffuse from one side of the membrane to the other.
- Porins pass molecules less then 5000 D.
- Ions, nutrient molecules, ATP, ADP etc can pass through the outer membrane with ease.
- The outer mitochondrial membrane is composed of about 50% phospholipids by weight and contains a variety of enzymes

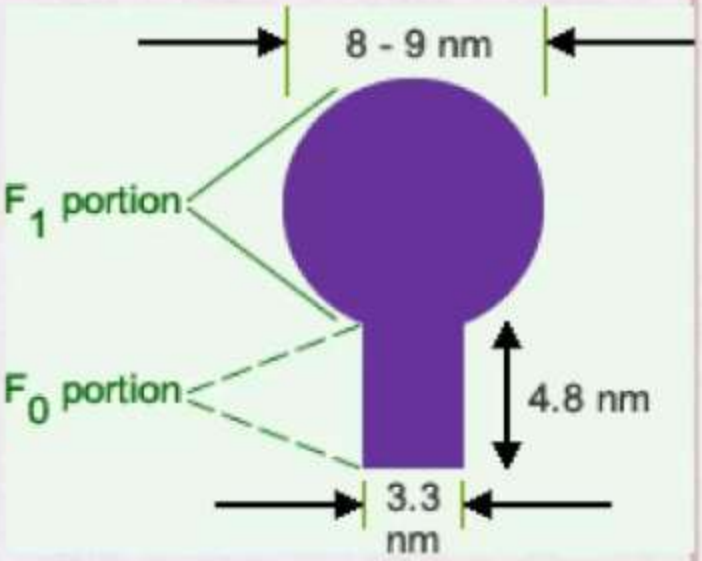
INTER MEMBRANE SPACE

- It is also known as **Perimitochondrial space**.
- The space between inner membrane and outer membrane .
- It has high proton concentration.
- The space between inner and outer membrane is approximately 70 A.
- Because the outer membrane is freely permeable to small molecules, the concentration of small molecules such as ions and sugars in the intermembrane space is same as that of the cytosol.
- Proteins present, participate in ATP synthesis but when released into the cytoplasm, trigger

INNER MEMBRANE

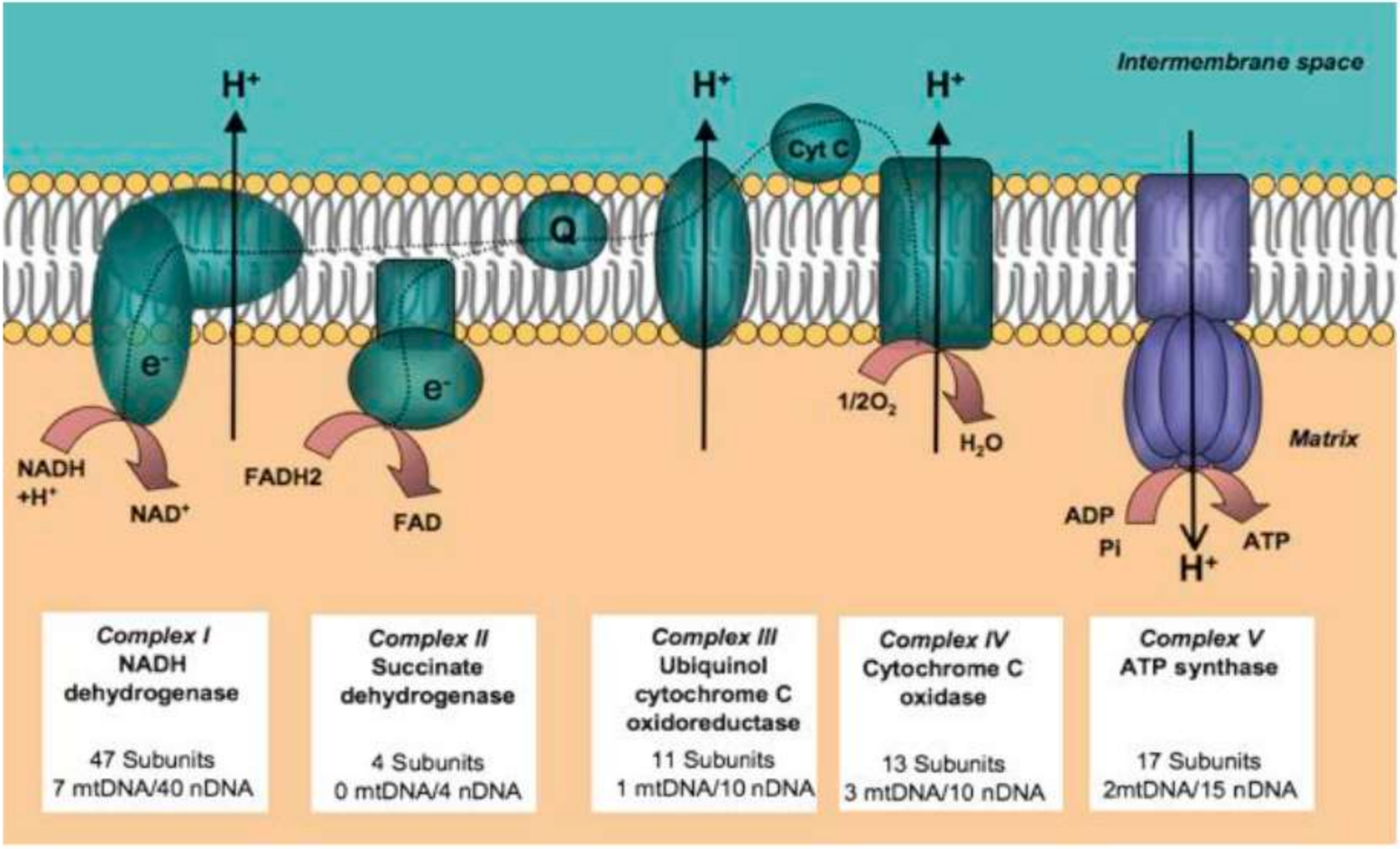
- Is freely permeable only to oxygen, CO_2 , H_2O.

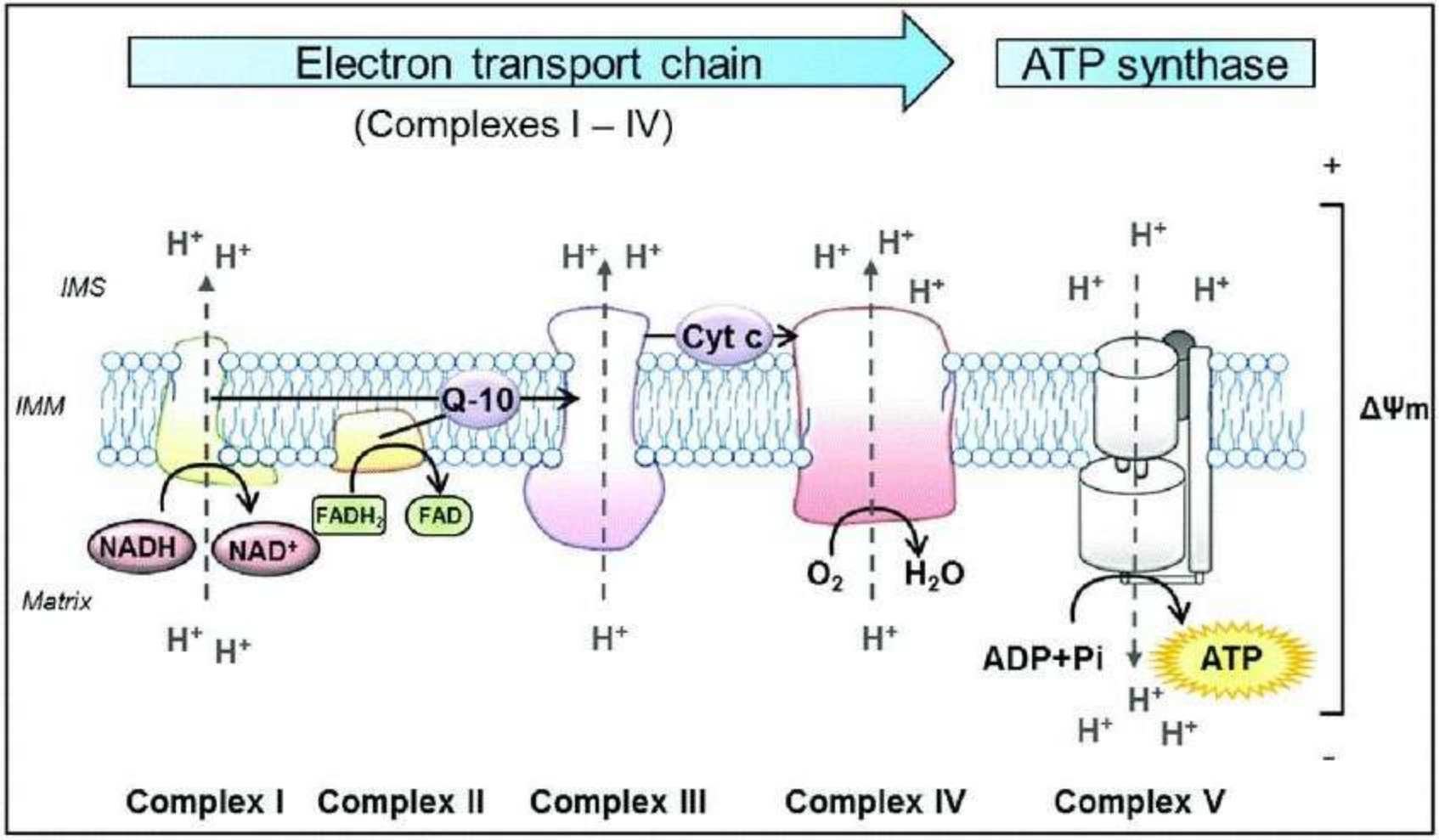
- The inner mitochondrial membrane contains proteins that perform **redox reactions in oxidative phosphorylation, ATP synthase,transport proteins, protein import machinery, mitochondria fusion and fission protein.**



- Several antiport systems exist , allowing exchange of anions between the cytosol and the mitochondrial

ETC in inner membrane




Electron transport chain
(Complexes I – IV)
ATP synthase
IMS
IMM
Matrix
H+
Q-10
Cyt c
NADH
NAD+
FADH2
FAD
O2
H2O
ADP+Pi
ATP
ΔΨm
+
-
Complex I
Complex II
Complex III
Complex IV
Complex V

CRISTAE

- Are folds of inner mitochondrial membrane, which expand its surface area , enhancing its ability to produce ATP.

- **Stalked particles or inner membrane spheres** :

  cristae is covered with this inner membrane

  spheres called stalked particles or knobs or

  heads.

MATRIX

- It is the space enclosed by the inner membrane.
- Gel like consistency ,Dense , homogenous.
- Contains 2/3 rd of total protein of mitochondria.
- Matrix have **enzymes, DNA genome, ribosomes, tRNA, granules, fibrils and tubules.**
- The matrix is important in the production of ATP with the aid of the ATP synthase contained in the inner membane.
- Major enzymes include enzymes involved in
  - Synthesis of nucleic acid and proteins.
  - Fatty acid oxidation

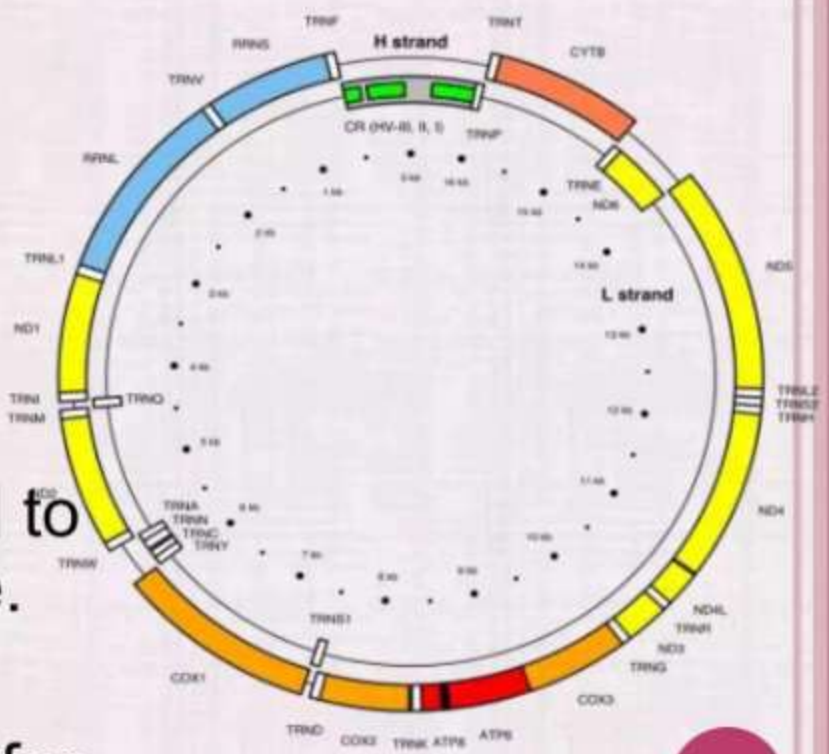
UNIQUE

- Mitochondria are unique in their own way containing their **own circular DNA and their own ribosomes.**

- The DNA in the cell nucleus does not code for the construction of mitochondria.

MITOCHONDRIAL DNA (MTDNA)

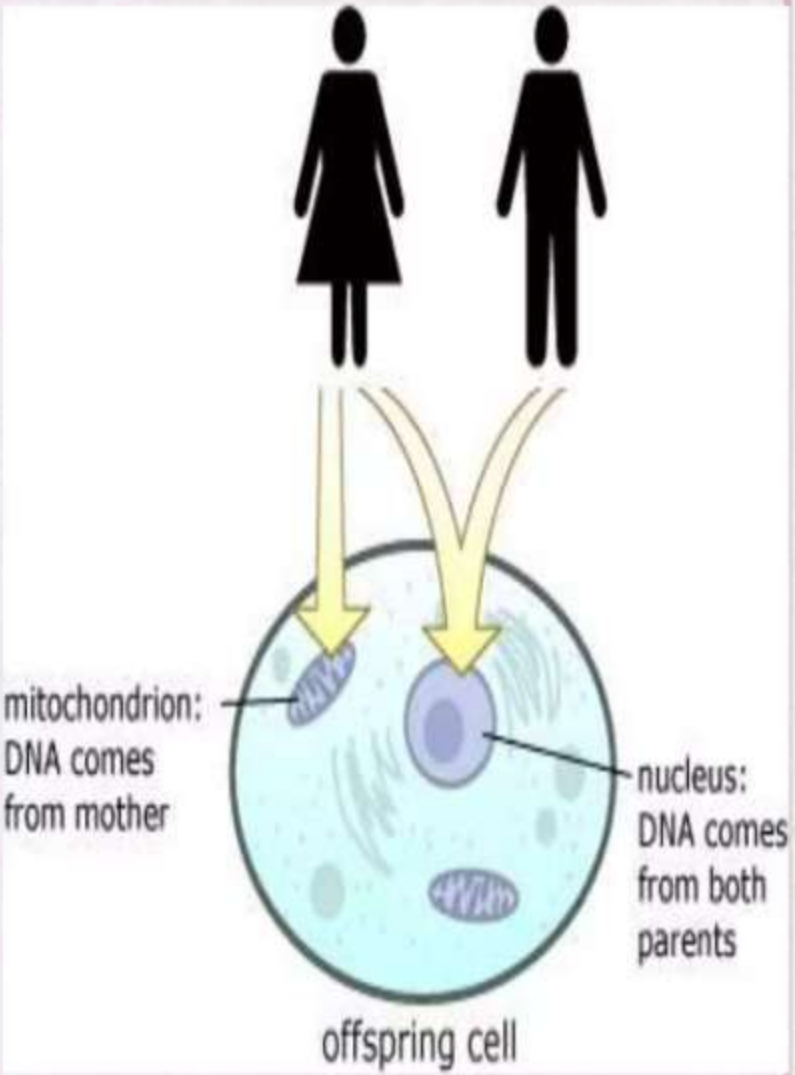
- Small, Double stranded ,covalently closed ,circular molecule.
- Occurs in multiple copies.
- It has 16569 bp.
- Most usually remains attached to inner mitochondrial membrane.
- Stores biological info required for growth and multiplication of mitochondria.



- Encode RNA s and proteins that are essential for mitochondrial function.
- It codes **2rRNAs , 22 tRNAs and 13 mitochondrial membrane proteins.**
- Can undergo replication and duplication.
- Not absolutely autonomous depends on nuclear DNA.

INHERITANCE OF MTDNA

- Mitochondrial DNA is **inherited maternally** in most animals.
- Fathers only give genes to their children but mothers give both genes and cytoplasm through their egg cell.
- Since mitochondria are in the cytoplasm and reproduce themselves they only are inherited from mothers.
- Hence this pattern of mtDNA inheritance is well known as " maternal inheritance".
- Geneticists have used this curious feature of



SITE OF SEVERAL METABOLIC REACTIONS

- OUTER MEMBRANE — Oxidation of epinephrine
  Degradation of tryptophan
  Elongation of fatty acid
- INNER MEMBRANE — Oxidative phosphorylation
- MATRIX — Kreb's cycle
  Beta oxidation
  Detoxification of ammonia in urea cycle
  Storage of calcium ions.

OTHER FUNCTIONS

- Production of heat(non shivering thermogenesis).
- Role in apoptosis (programmed cell death).
- Synthesis of estrogen and testosterone.
- Role in neurotransmitter metabolism.
- Role on cholesterol metabolism.
- Role in heme synthesis.
- Role in cellular proliferation