

# Mitochondria

## Mitochondria Structural Features

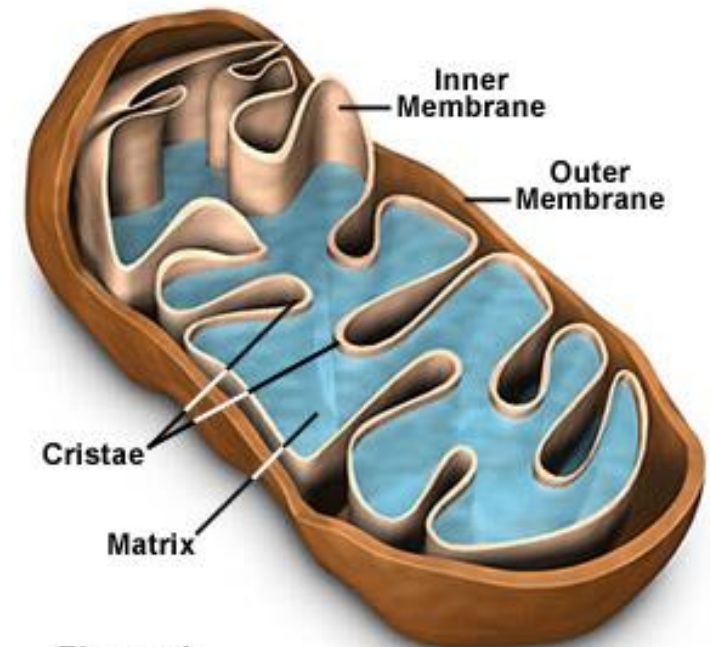


Figure 1

**Dr. Rupesh B. Yadav**

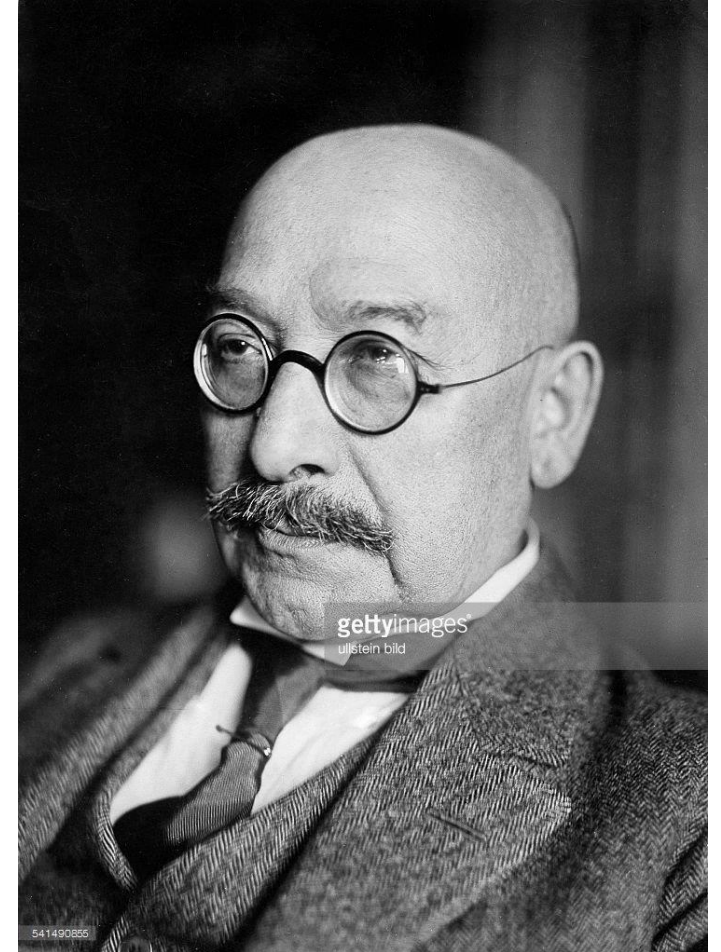
Asst. Prof.

TCSC, Mumbai.

# Mitochondria

## Discovery

- It was first described by a German pathologist named **Richard Altmann** in **the year 1890.**
- The term "mitochondria" was coined by **Carl Benda** in **1898.**

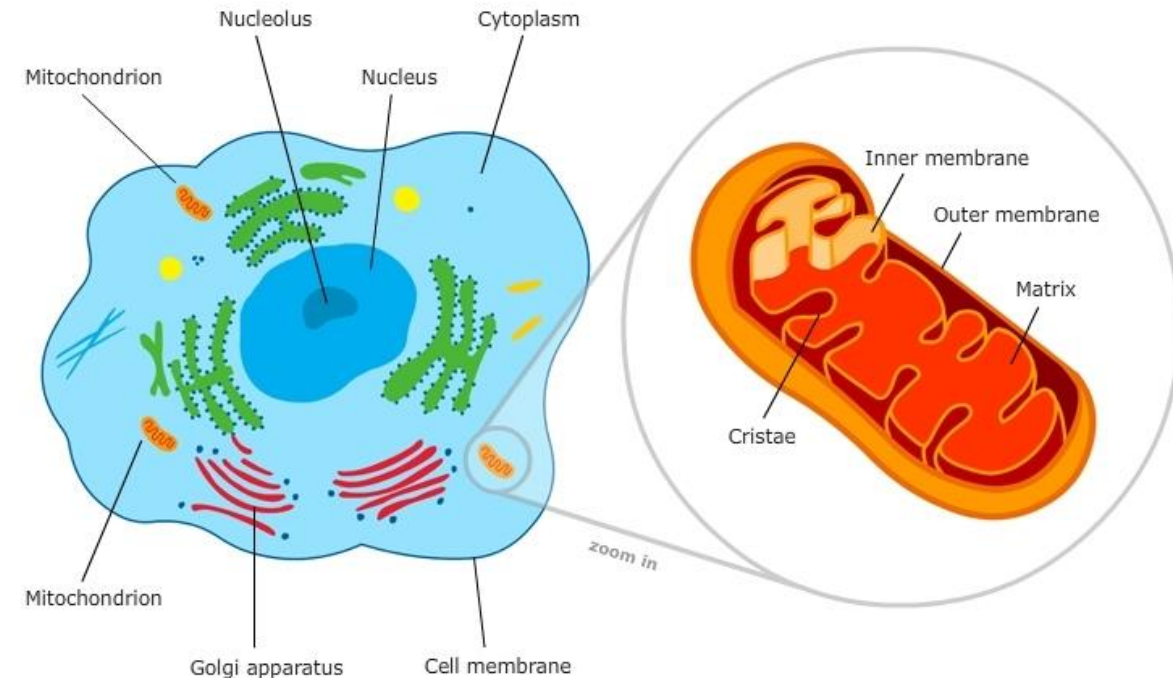


**Carl Benda**

# Mitochondria

## Definition

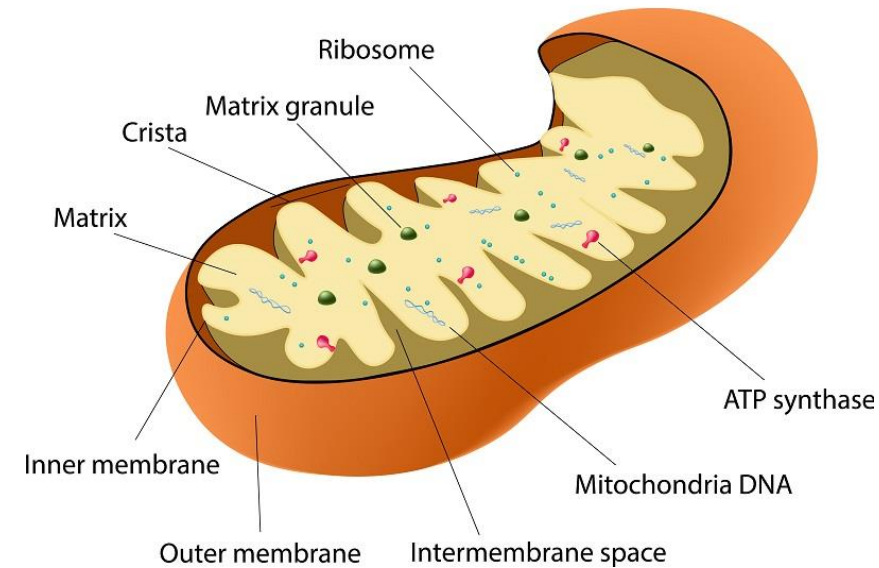
- “Mitochondria are membrane-bound organelles present in the cytoplasm of all eukaryotic cells, that produces adenosine triphosphate (ATP), the main energy molecule used by the cell.”



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# Introduction

- Mitochondria are membrane bound cell organelles, associated with **cellular respiration**, the **source of energy**, being termed as **power houses of cell**.
- These are bean-shaped organelles, **1 to 10  $\mu\text{m}$  long and about 0.5  $\mu\text{m}$  wide**, occur free in the cytoplasm.
- The **life span** of a mitochondrion is **5-10 days**.
- **Double membrane-bound organelle**
- They are found inside the cytoplasm and essentially functions as the cell's **“digestive system.”**

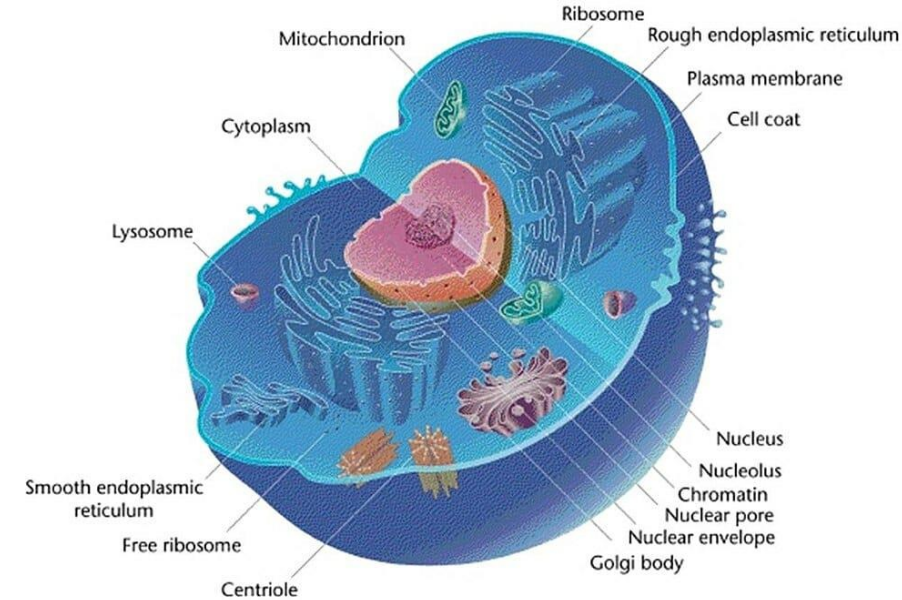


# Introduction

- They play a major role in **breaking down nutrients** and generating energy-rich molecules for the cell.
- Many of the **biochemical reactions** involved in cellular respiration take place within the mitochondria.
- The term 'mitochondrion' is derived from the Greek words "**mitos**" and "**chondrion**" which means "**thread**" and "**granules-like**" respectively.
- Since mitochondria act as the power-houses, they are **abundantly found** on those sites where **energy is highly required** such as sperm tail, muscle cell, liver cell (up to 1600 mitochondria), microvilli, oocyte (**more than 300,000 mitochondria**), etc.
- Typically, there are about 2000 mitochondria per cell, representing **around 25% of the cell volume**.

# Origin

- There are **numbers of hypotheses** about the origin of mitochondria.
- 1. The **Endosymbiotic hypothesis** suggests that **mitochondria were originally prokaryotic cells**, capable of implementing **oxidative mechanisms** that were not possible for eukaryotic cells.
- 2. The **Autogenous hypothesis**, **mitochondria were born by splitting off a portion of DNA** from the **nucleus of the eukaryotic cell** at the time of divergence with the prokaryotes, this DNA portion would have been enclosed by membranes, which could not be crossed by proteins.

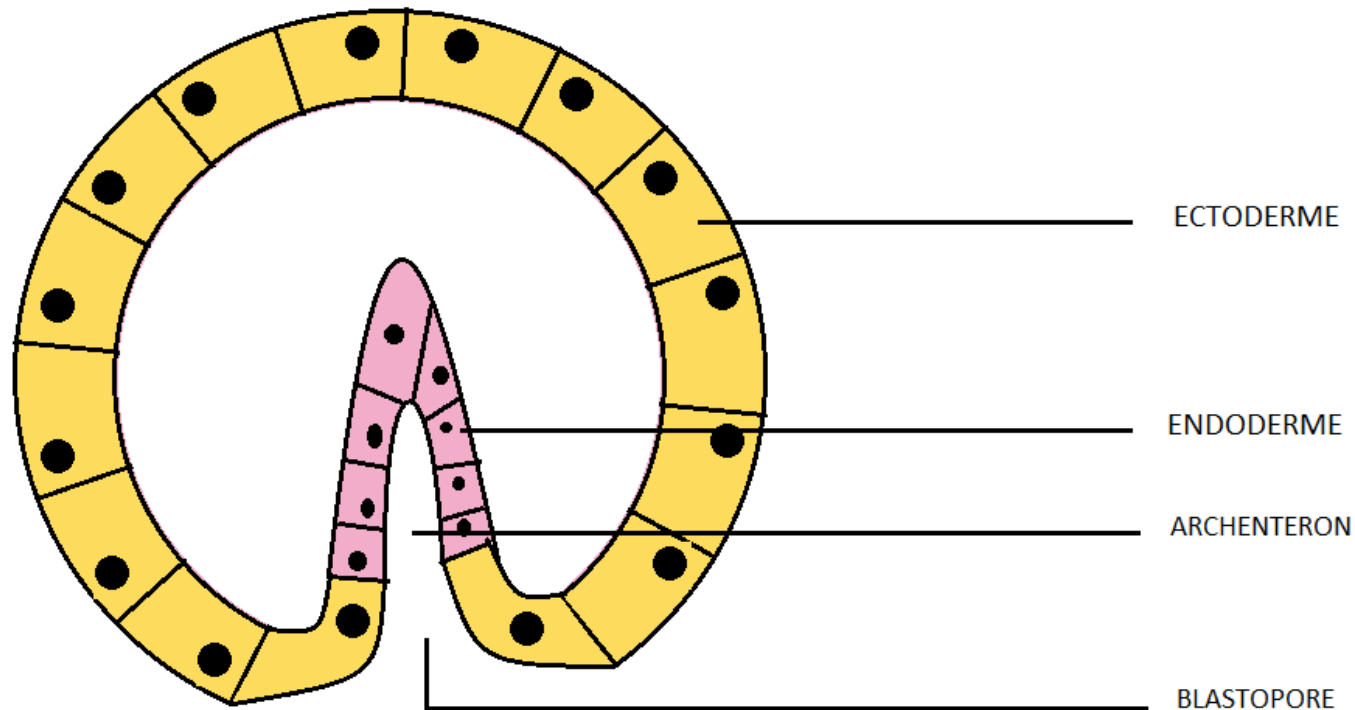


# Origin

## ➤ 3. Mitochondrial formation from other Intracellular Structure:

In this case, the mitochondria are originated by invagination of cell membrane  
(Green – 1956 and Robert 1964)

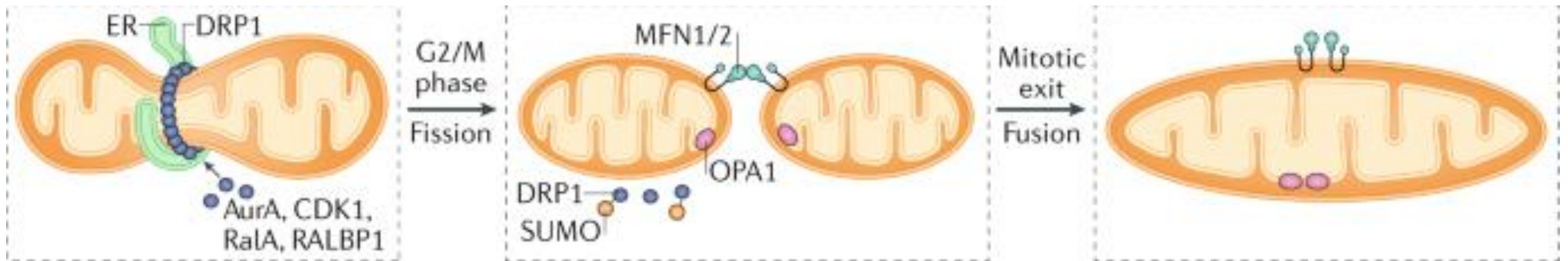
INVAGINATION



# Origin

## ➤ 4. Formation of Growth & division of Pre-existing mitochondria:

This was established by using labelled choline in requiring mutant.

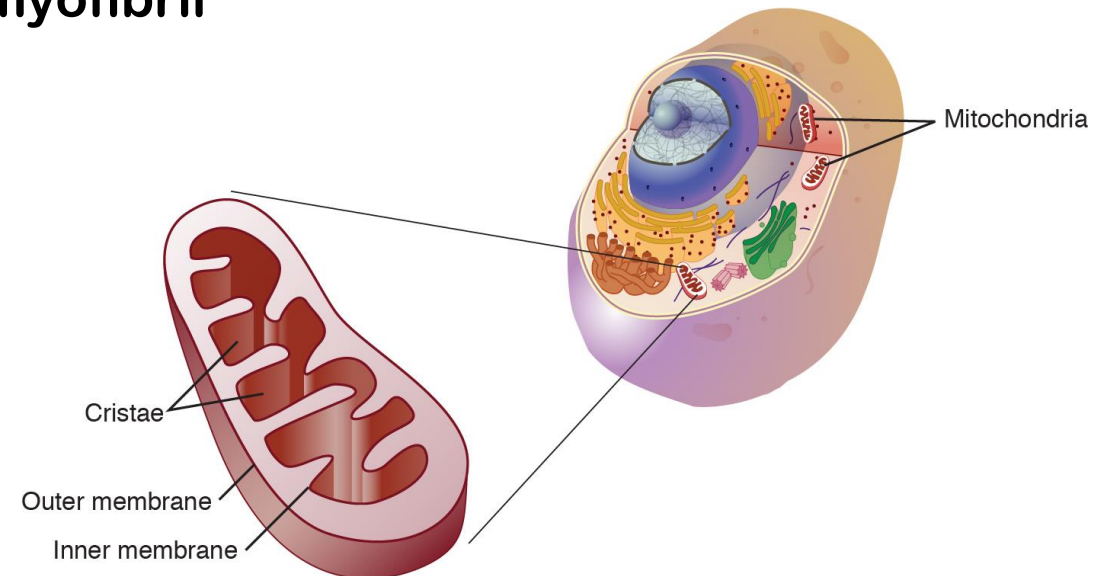


## ➤ 5. De novo origine of mitochondria:

There is no evidence that mitochondria arise de novo (afresh), hence this hypothesis has been discarded

# Occurrence

- Distributed in cell cytoplasm.
- In some cases, they are aggregated around the nucleus
- In Paramecium they located in beneath the cell surface.
- In Skeletal muscle they lie between the myofibril
- During cell division, they accumulated about the spindle and upon division of the cell.

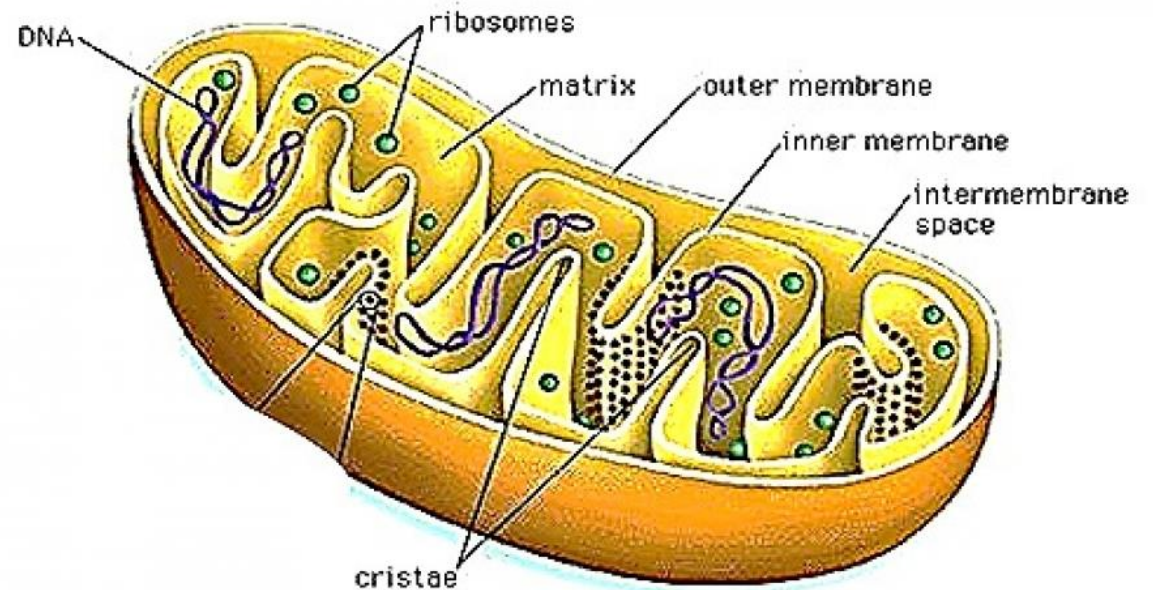


# Morphology

- **Mitochondria vary in shape: Rod Shaped, Granular or filamentous**
- **Average length : 3 – 4  $\mu$  & 0.5 – 1.0 in diameter**
- **The different physical and chemical factor such as pH, cell environment, and osmotic pressure influences the size and shape of mitochondria.**
- **The mitochondria vary depending up-on the cell type**
- **In Giant Amoeba – Chaos chaos – 5 lakh Mitochondria, Large Sea Urchin – 13,000 to 14,000 Mitochondria recorded.**

# Structure

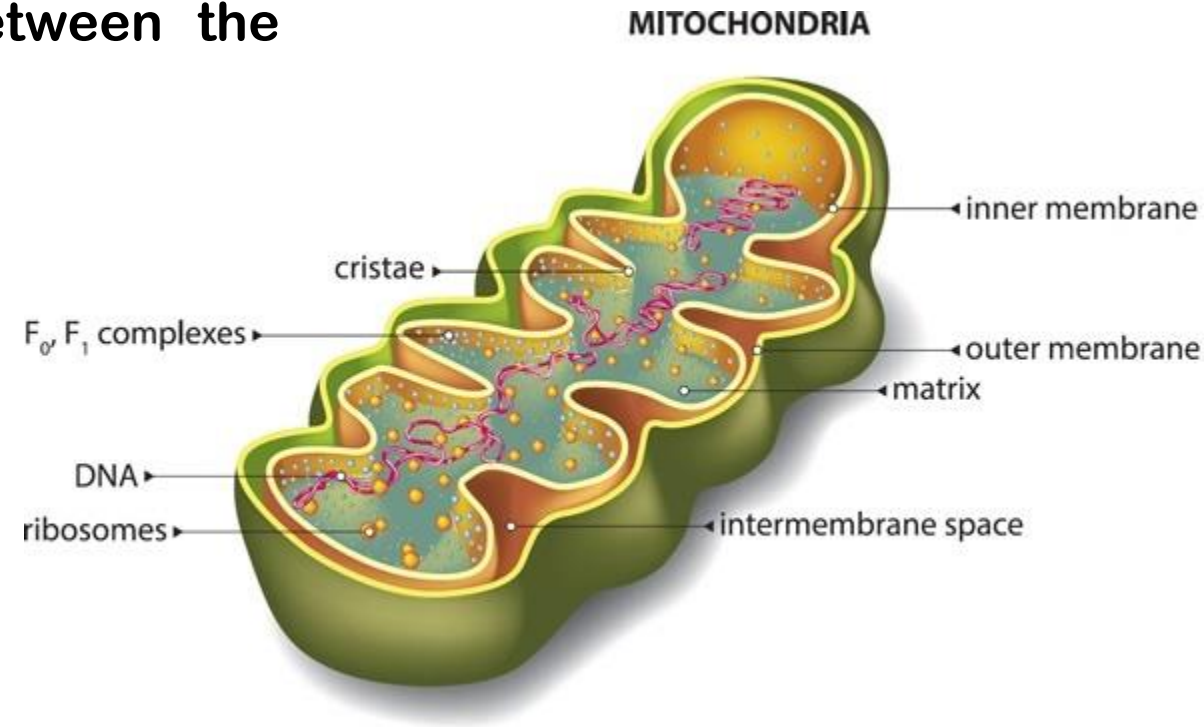
- **Mitochondria are mobile**, plastic organelles that have a double-membrane structure.
- It has **four distinct domains**: the **outer membrane**, the **inner membrane**, the **intermembrane space**, and the **matrix**.
- The **organelle is enclosed by two membranes**—a smooth outer membrane and a markedly folded or tubular inner mitochondrial membrane, which has a large surface and encloses the matrix space.



**MITOCHONDRIA-  
STRUCTURE**

# Structure

- The **intermembrane space** is located between the inner and outer membranes.
- The **number and shape** of the mitochondria, as well as the numbers of cristae they have, can **differ widely from cell type to cell type**.
- Tissues with intensive oxidative metabolism— e. g., heart muscle—have mitochondria with particularly large numbers of cristae.



# Structure

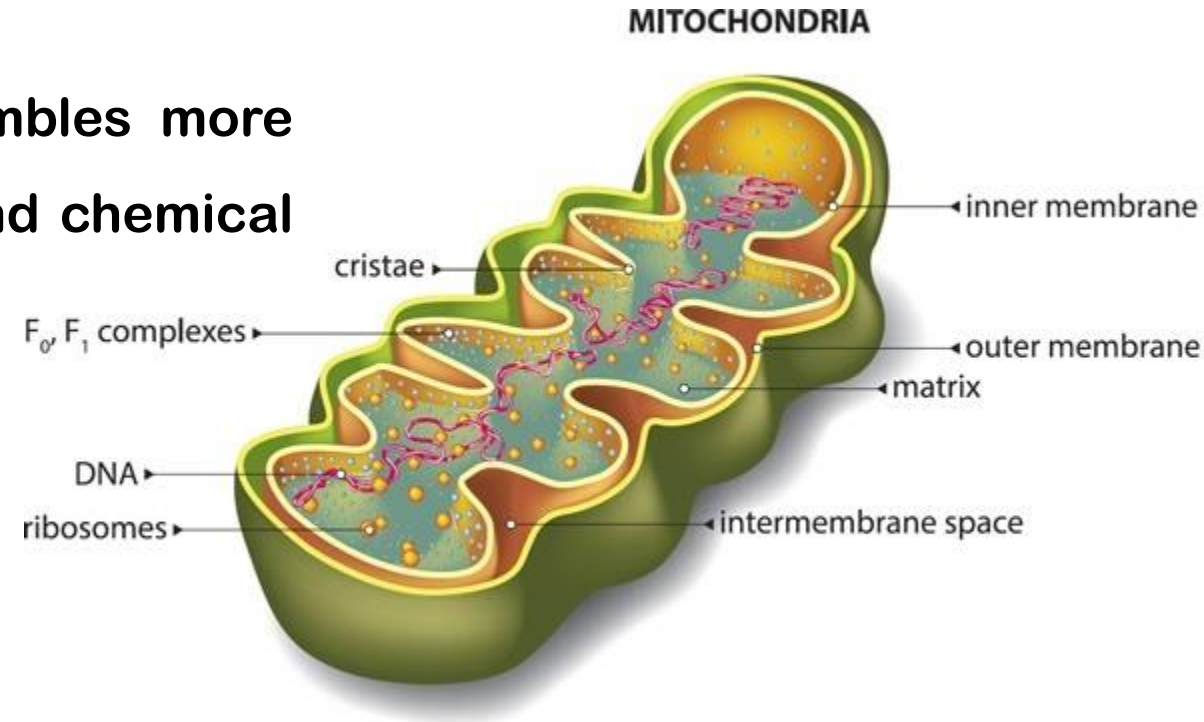
- Even within one type of tissue, the shape of the mitochondria can vary depending on their functional status.
- Both mitochondrial membranes are very rich in proteins.



# Structure

## Outer Mitochondrial Membrane

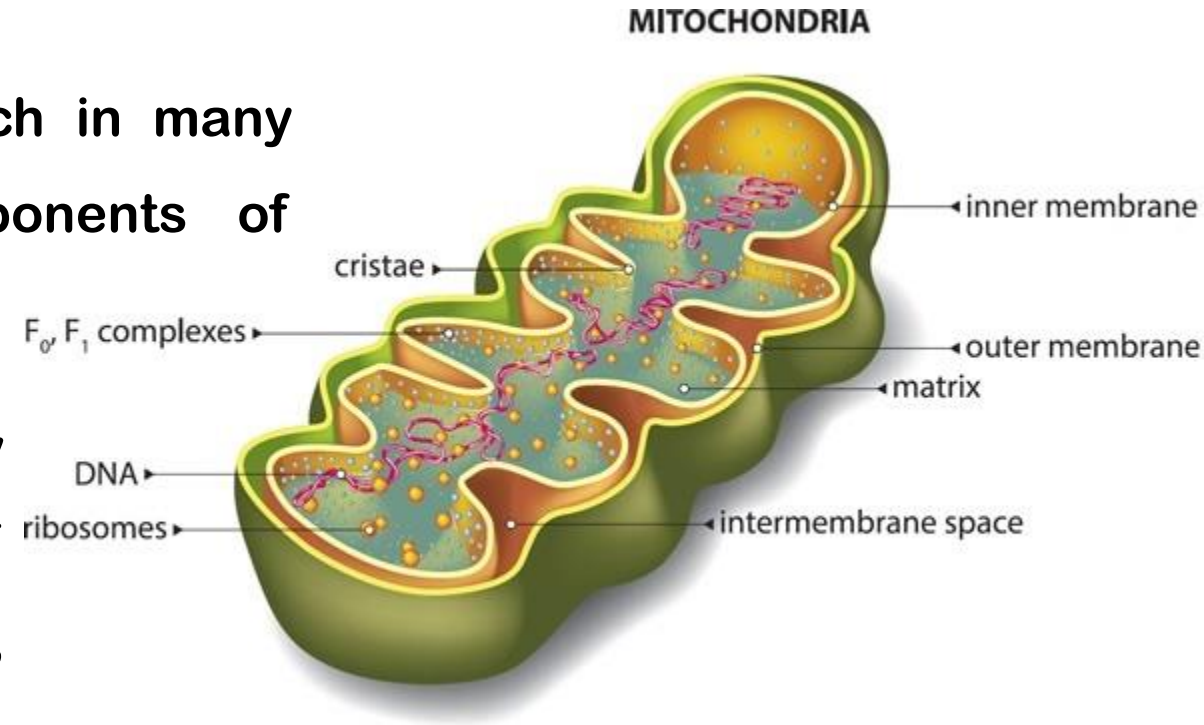
- The outer mitochondrial membrane resembles more with the plasma membrane in structure and chemical composition.
- Porins in the outer membrane allow small molecules to be exchanged between the cytoplasm and the intermembrane space.



# Structure

## Inner Mitochondrial Membrane

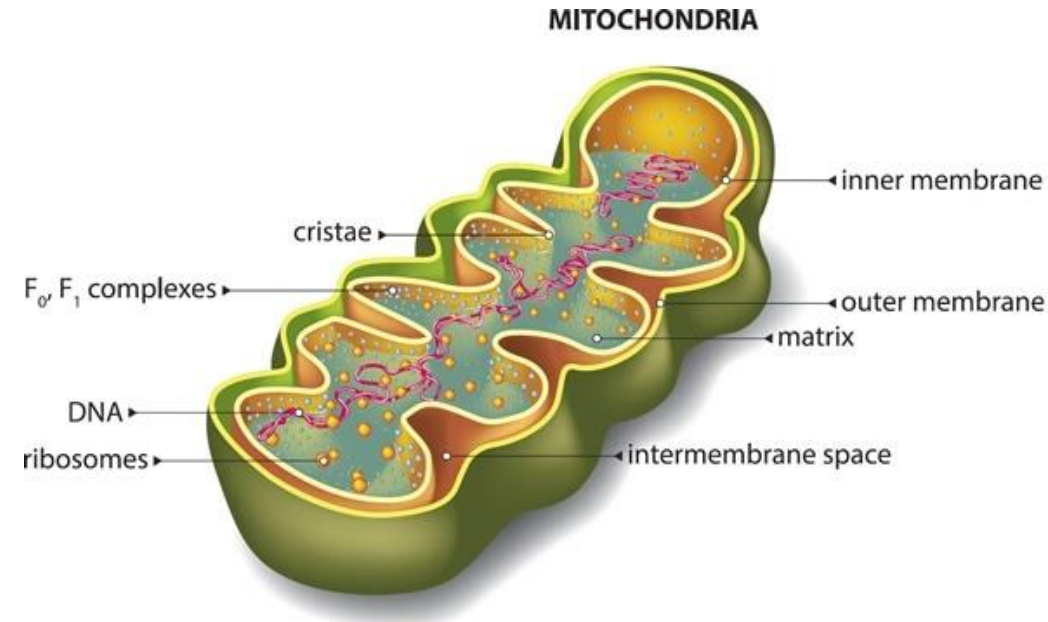
- The inner mitochondrial membrane is rich in many enzymes, coenzymes, and other components of electron transport chain.
- It also contains proton pumps and many permease proteins for the transport of various molecules such as citrates, ADP, phosphate, and ATP.
- It also contains proton pumps and many



# Structure

## Inner Mitochondrial Membrane

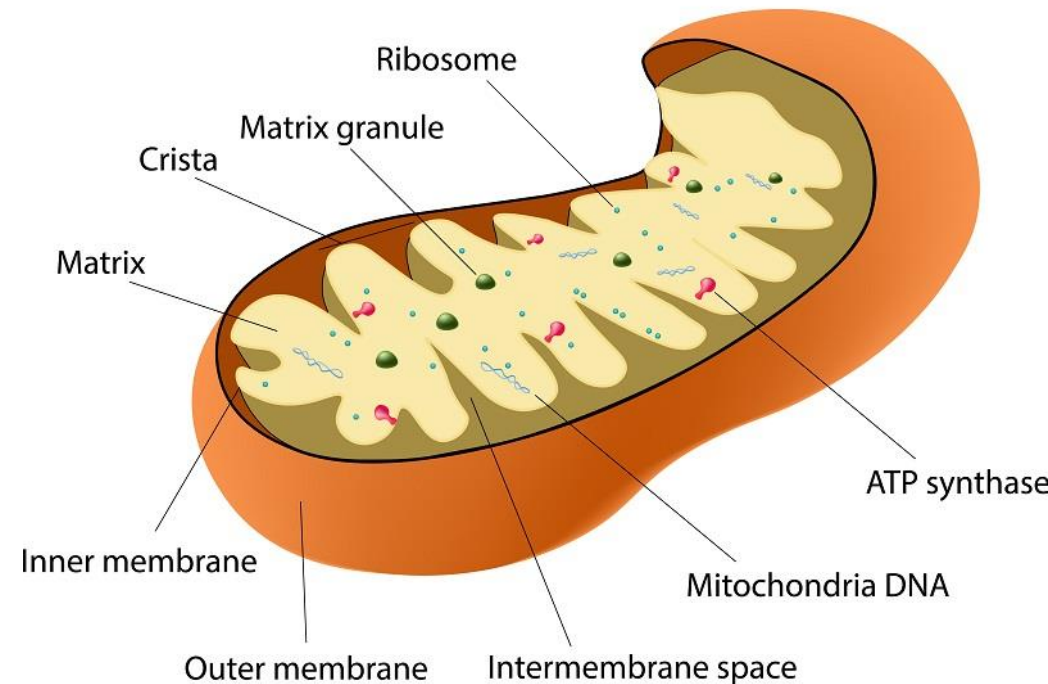
- The inner mitochondrial membrane gives out finger-like outgrowths (cristae) towards the lumen of the mitochondrion and contains tennis-racket shaped  $F_1F_0$  particles that contain ATP-ase enzyme for ATP synthesis.
- The inner mitochondrial membrane is completely impermeable even to small molecules (with the exception of  $O_2$ ,  $CO_2$ , and  $H_2O$ ).
- Numerous transporters in the inner membrane ensure the import and export of important metabolites.



# Structure

## Intermembrane Space

- It is the space between the outer and inner membrane of the mitochondria, it has the same composition as that of the cell's cytoplasm.
- There is a difference in the protein content in the intermembrane space.

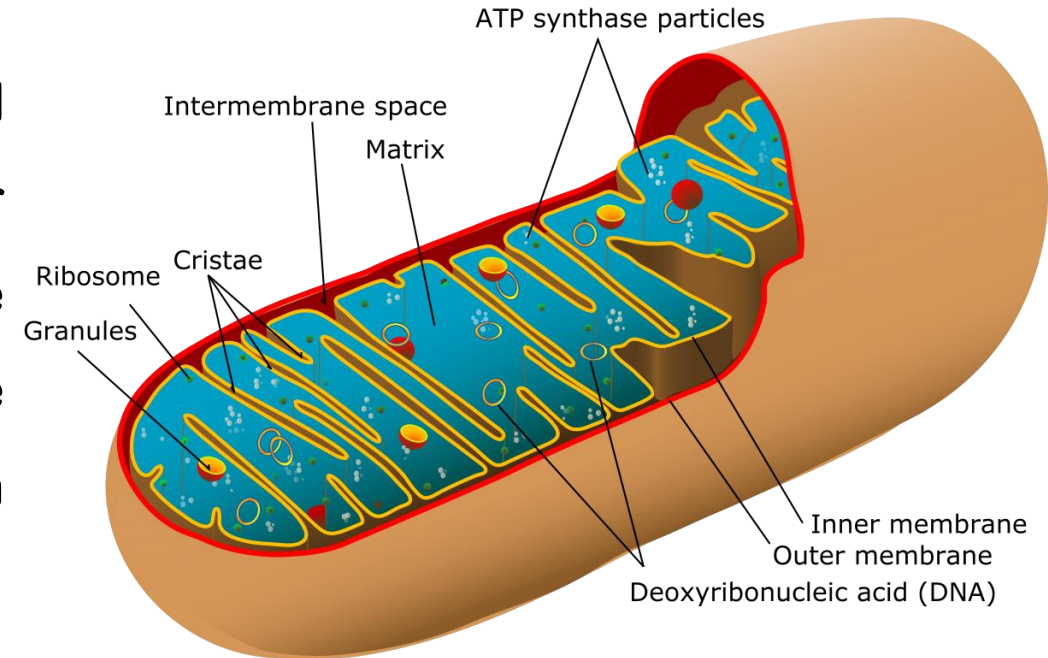


# Structure

## Mitochondrial Matrix

➤ The mitochondrial matrix which is the liquid (colloidal) area encircled by the inner membrane, contains the soluble enzymes of the **Krebs cycle** which completely oxidize the acetyl-CoA to produce CO<sub>2</sub>, H<sub>2</sub>O and hydrogen ions.

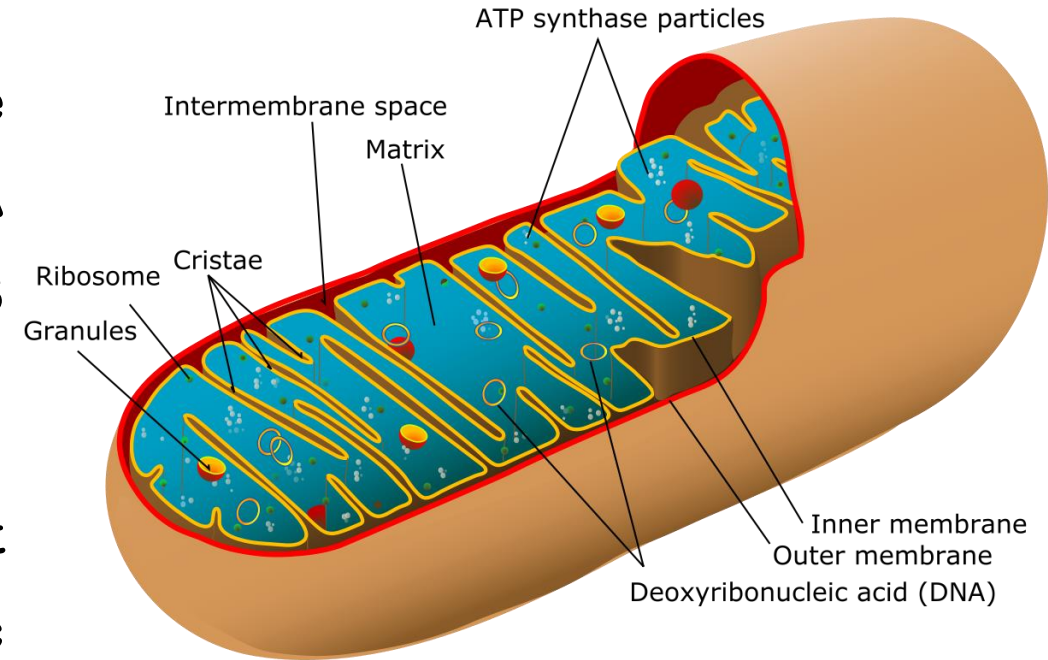
➤ Hydrogen ions reduce the molecules of NAD and FAD, both of which pass on hydrogen ions to respiratory or electron transport chain where oxidative phosphorylation takes place to generate energy-rich ATP molecules.

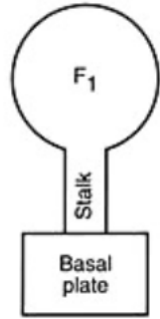


# Structure

## Mitochondrial Matrix

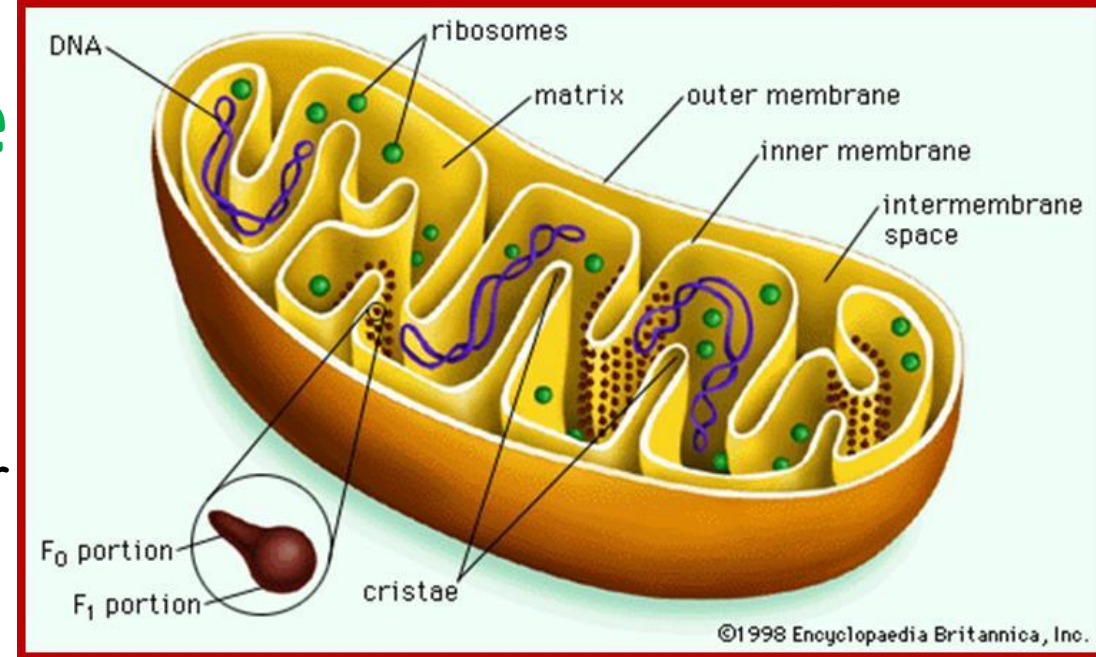
- Mitochondria also contain in their matrix single or double circular and double-stranded DNA molecules called mt DNA and also the 55S ribosomes, called mito-ribosomes.
- Since mitochondria can synthesize 10 percent of their proteins in their own protein-synthetic machinery, they are considered as semi-autonomous organelles.





# Structure

## Cristae



- The cristae space (formed by infoldings of the inner membrane)
- The inner mitochondrial membrane is compartmentalized into numerous cristae, which expand the surface area of the inner mitochondrial membrane, enhancing its ability to produce ATP.
- Mitochondria of cells that have greater demand for ATP, such as muscle cells, contain more cristae than typical liver mitochondria.
- These folds are studded with small round bodies known as F1 particles or oxysomes.
- It has many folds that form a layered structure called cristae, and this helps in increasing the surface area inside the organelle.

# Function of Mitochondria

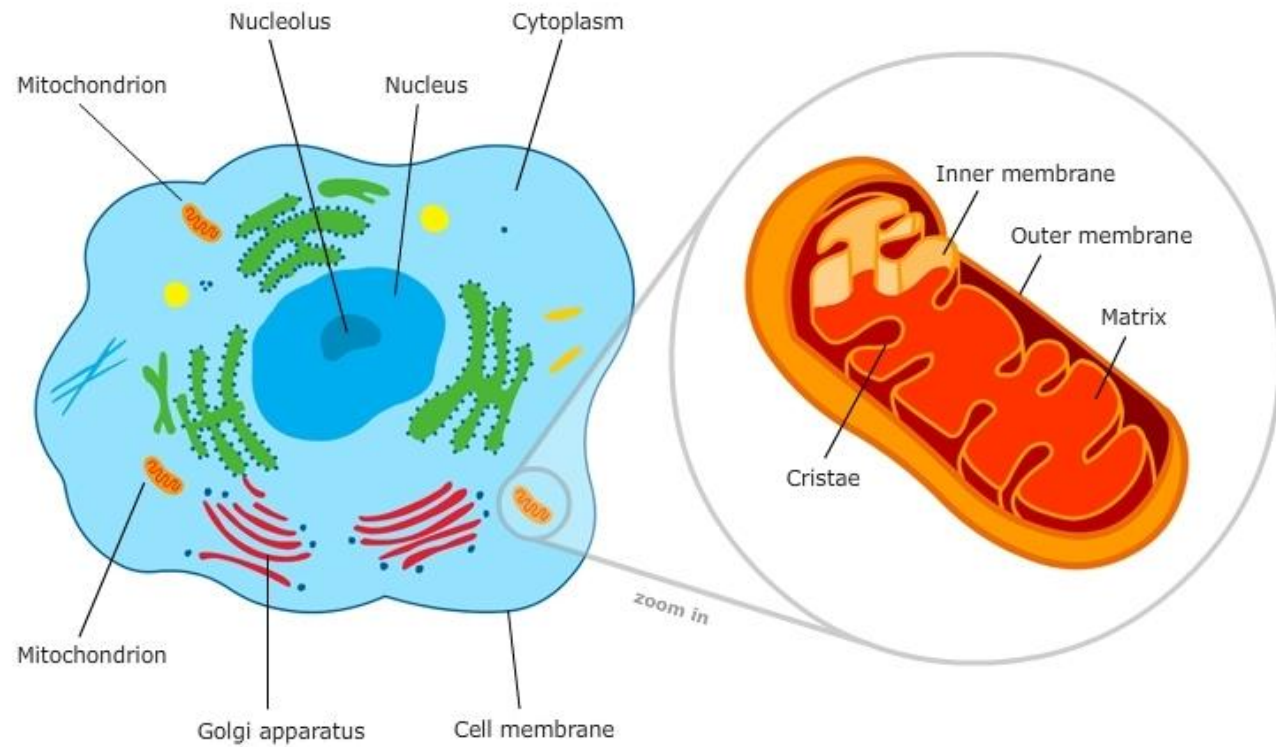
- **The most important function of mitochondria is to produce energy. Mitochondria produce the molecule adenosine triphosphate (ATP), one of the cell's energy currencies that provide the energy to drive a host of cellular reactions and mechanisms.**
- **The simpler molecules of nutrition are sent to the mitochondria to be processed and to produce charged molecules. These charged molecules combine with oxygen and produce ATP molecules. This process is known as oxidative phosphorylation.**

# Function of Mitochondria

- Mitochondria may also produce heat (brown fat), and accumulate iron-containing pigments (Heme ferritin), ions of  $\text{Ca}^{2+}$  and  $\text{HPO}$  (or phosphate; e.g., osteoblasts of bones or yolk proteins).
- Mitochondria help the cells to maintain the proper concentration of calcium ions within the compartments of the cell.
- The mitochondria also help in building certain parts of blood and hormonelike testosterone and estrogen.
- The liver cell's mitochondria have enzymes that detoxify ammonia.

# Function of Mitochondria

- The mitochondria also play an important role in the process of apoptosis or programmed cell death.
- Abnormal death of cells due to the dysfunction of mitochondria can affect the function of an organ.
- It is also involved in various cellular activities like cellular differentiation, cell signaling, cell senescence, controlling the cell cycle and also in cell growth.
- Helps in the process of Vitellogenesis



*Thank  
You*