CELL BIOLOGY, GENETICS AND BIOTECHNOLOGY

II B.Sc BOTANY (ALLIED ZOOLOGY)

BY

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UNIT I

Ultrastructure and functions of-

1. **Plasma membrane**
2. **Mitochondria**
3. **Nucleus**

Chromosomes-

1. **Structure**
2. **Types**
3. **Functions**

Giant chromosomes(Polytene and Lampbrush chromosomes)

MITOCHONDRIA

Mitochondria

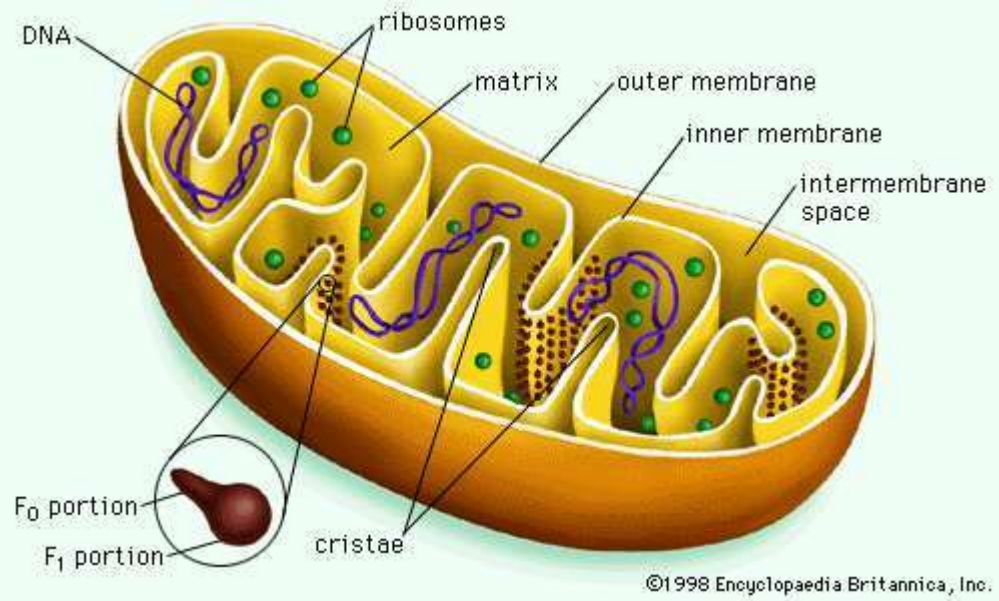
Introduction

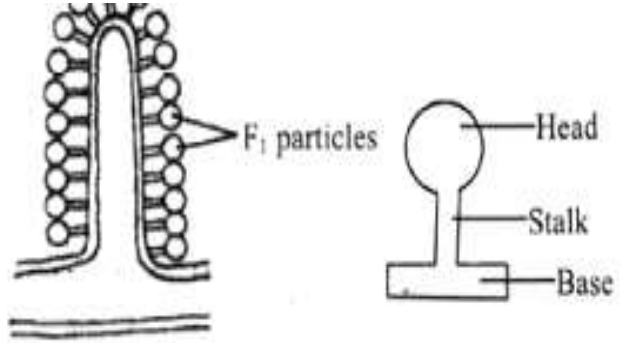
- The mitochondria are thread-like or granular cytoplasmic organelles
- They contain many enzymes and coenzymes which are responsible for energy metabolism
- They are described as the power plants or power houses of cells
- The mitochondria were first observed by Flemming and Kolliker in 1882
- Mitochondria are found both in plant and animal cells
- But they are absent from prokaryotes

Structure of Mitochondria

- The mitochondria are covered by two unit membranes, namely an outer and an inner mitochondrial membranes
- Each measuring about 60A° in the thickness
- The space between the outer and inner mitochondrial membranes is called outer chamber
- This chamber is filled with a fluid
- The central space of the mitochondria is called the inner chamber
- The inner chamber is filled with mitochondrial matrix
- The matrix may contain filamentous materials
- The inner mitochondrial membrane gives out certain finger like projections known as cristae

- The mitochondrial membrane contains small particles called F1 particles
- The particles of the inner membrane are stalked
- Each stalked particle consists of a base piece, a stem and a head
- They are regularly placed at a distance of 100A°

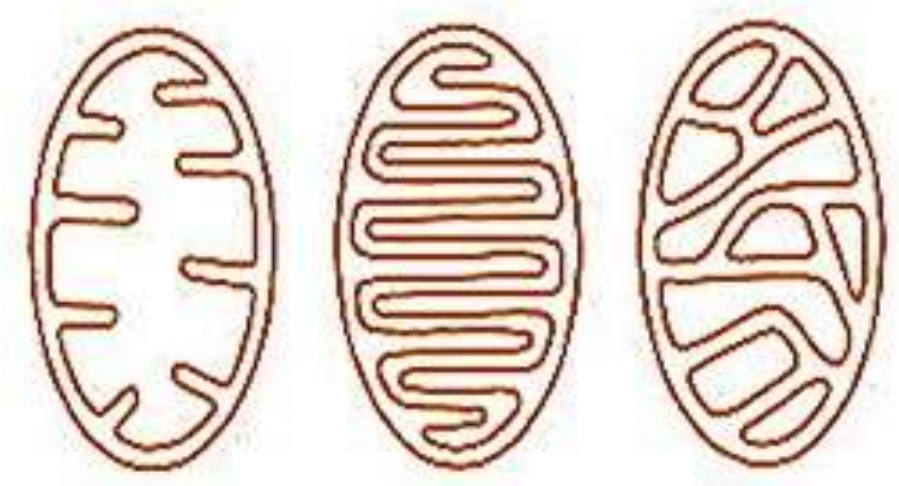




Ultrastructure of F_1 particle

- The cristae are variously arranged
- In Frogs, they are longitudinal
- In the adrenal cortex, the cristae are transverse
- They are network like in the WBC of man

transverse cristae longitudinal cristae network cristae



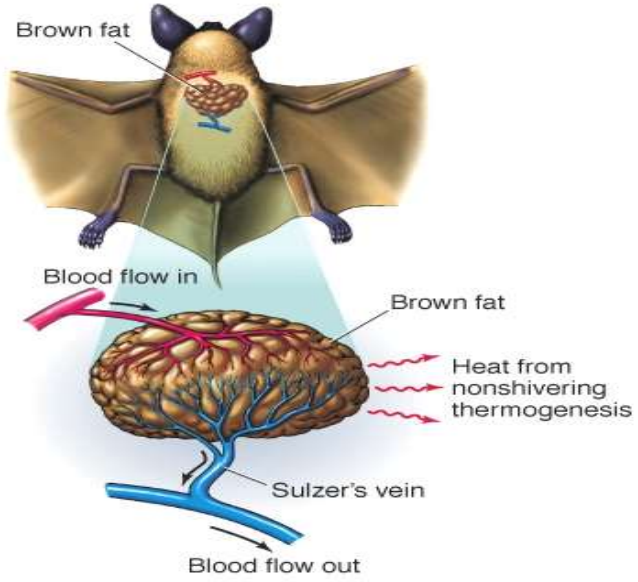
Functions of Mitochondria

Mitochondria performs the following functions:

1. Thermogenesis
2. Protein synthesis
3. Synthesis of steroid hormones
4. Urea cycle
5. Calcium accumulation
6. Energy supply
7. Cellular respiration
8. Oxidative decarboxylation
9. Kreb’s cycle
10. Electron transport system
11. Oxidative phosphorylation

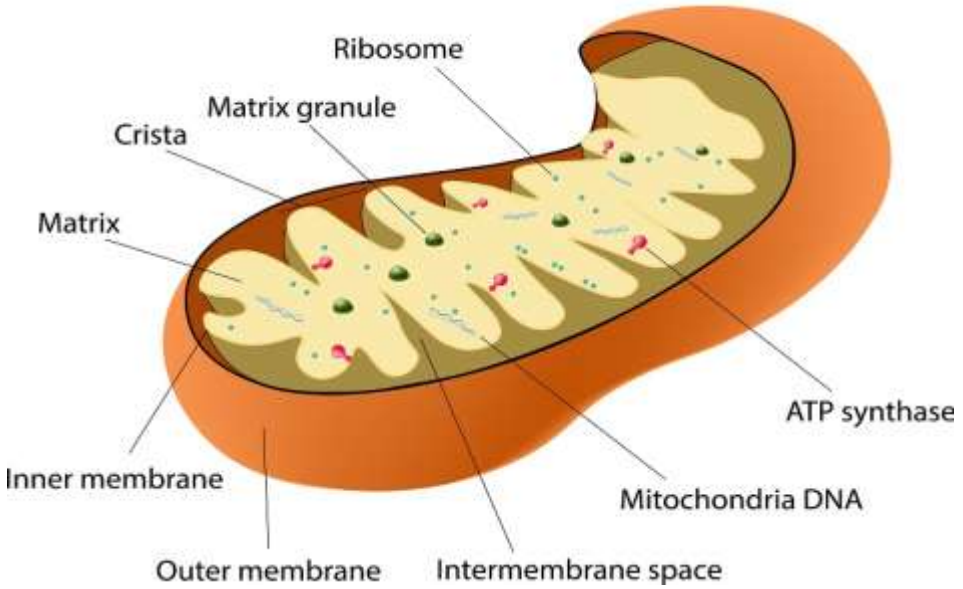
1. Thermogenesis

- In young mammals and hibernating mammals such as bats, there is a special tissue in the chest region
- It is called brown fat
- It consists of extensive vascularization and numerous mitochondria
- It functions as an automatic furnace and generates enormous heat
- Here mitochondria are concerned with the release of heat energy



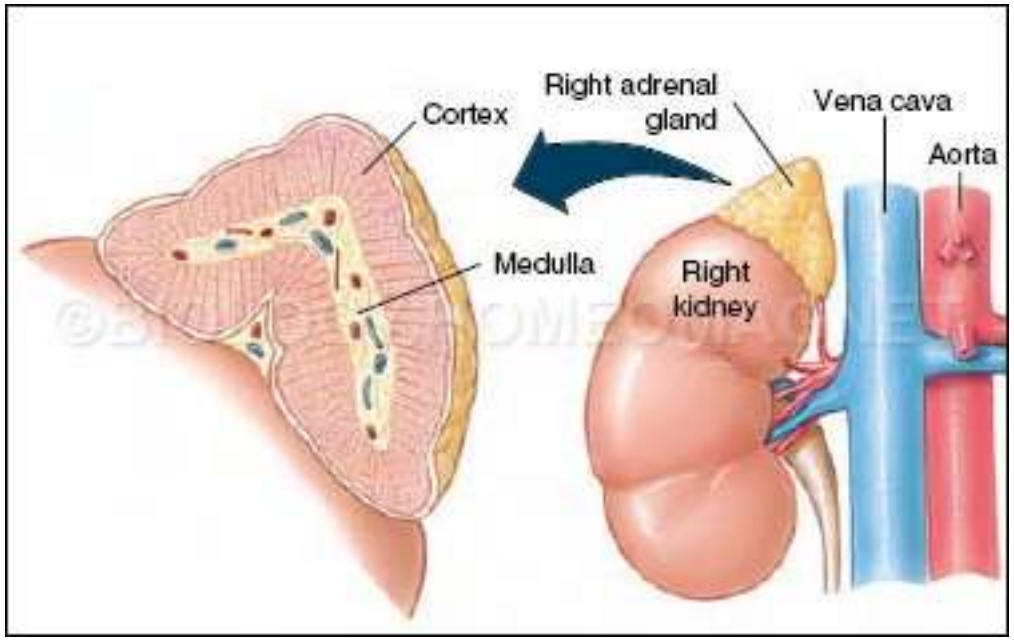
2. Protein synthesis

- Mitochondria contain DNA
- About 5 to 10% of proteins of mitochondria are synthesized by the mitochondrial genes



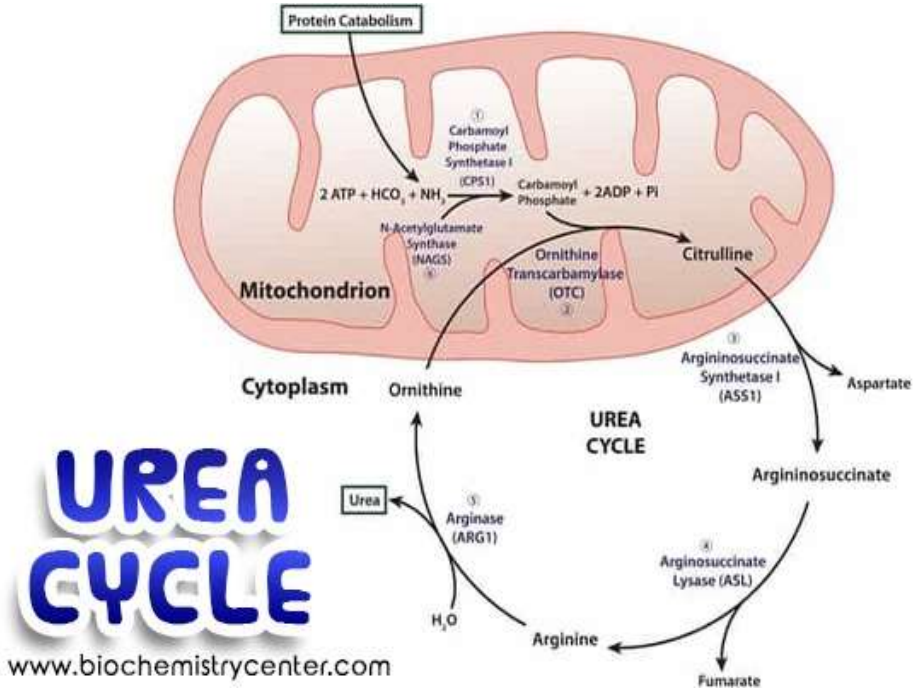
3. Synthesis of Steroid hormones

- The early steps in the conversion of cholesterol to steroid hormones in the adrenal cortex are catalyzed by mitochondrial enzymes



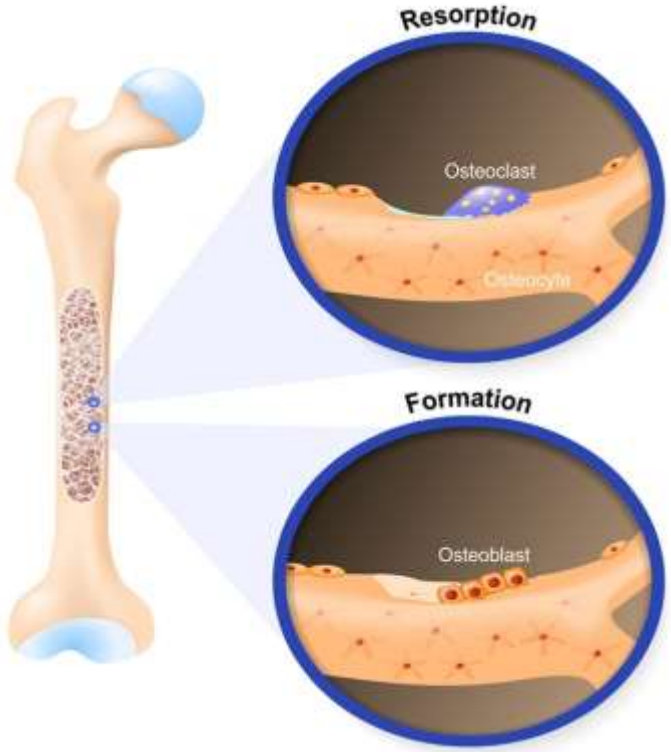
4. Urea cycle

- In urea cycle, urea is synthesized
- The first step of the urea cycle, that is the conversion of ornithine to citrulline occurs in the mitochondria



5. Calcium accumulation

- One of the important functions of mitochondria is the accumulation of calcium
- This process usually occurs in the osteoblast during the formation of bone



6. Energy supply

- Mitochondria are the energy plants of the cell
- Mitochondria synthesize the energy rich compound , ATP
- It is stored inside the mitochondria
- When a site is in need of energy, mitochondria get collected around the site
- The mitochondrial membrane contracts and squeezes out ATPs

7. Cell respiration

- Mitochondria are the respiratory centres of the cell
- They bring about the oxidation of the various food stuffs such as carbohydrates, fats and proteins

- During oxidation, the food stuffs are degraded to CO_2 and water with the release of energy
- This energy is utilized by the mitochondria for the synthesis of energy rich compound called ATP

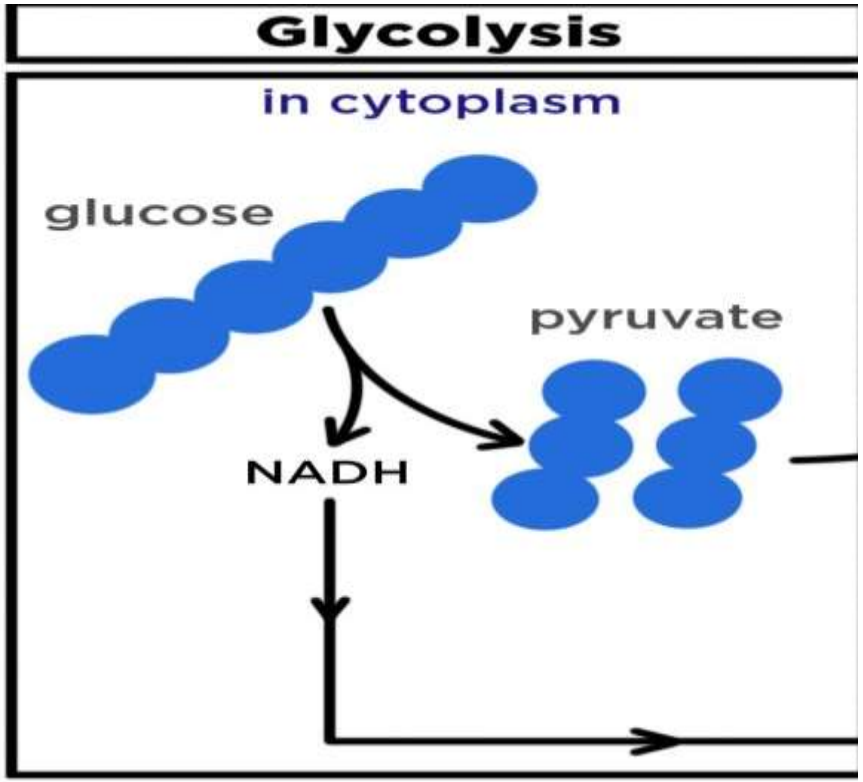
The release of energy during cellular respiration

- The cell respiration involves the following steps:

1. Glycolysis
2. Oxidative decarboxylation
3. Kreb’s cycle
4. Electron transport system
5. Oxidative phosphorylation

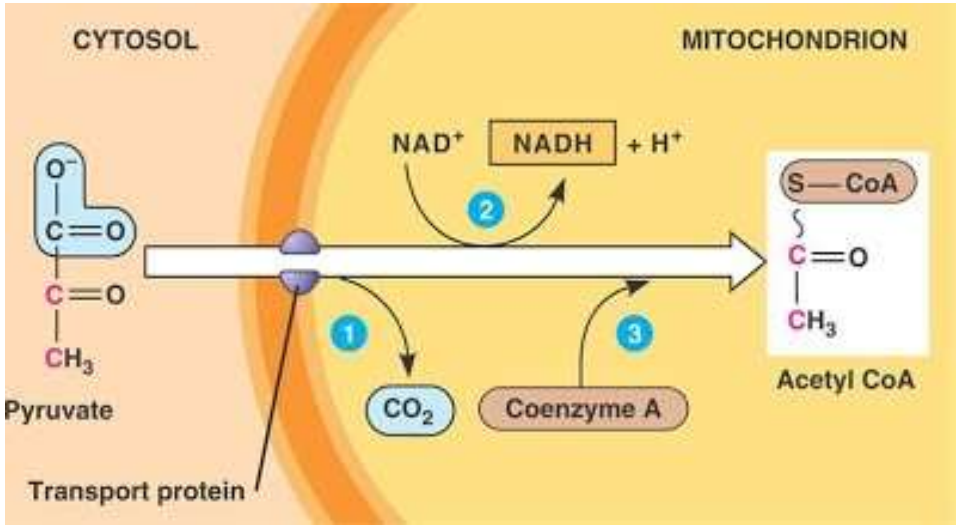
1. Glycolysis

- Glycolysis occurs inside the cytoplasm but outside mitochondria
- Glycolysis does not require oxygen and hence it is an anaerobic process
- Glycolysis is a series of enzymatic reactions which convert glucose into pyruvic acid
- It is also called Embden-Meyerhof pathways



2. Oxidative decarboxylation

- The pyruvic acid produced during glycolysis enters the mitochondria
- It is degraded to acetyl CoA by oxidation and decarboxylation



3. Kreb's Cycle

- The degradation of acetyl CoA into oxaloacetic acid through a series of steps is called Krebs cycle
- It is an aerobic process and it occurs inside the mitochondria

4. Electron transport system

- The hydrogen pairs released in glycolysis, oxidative decarboxylation and kreb's cycle are oxidized in electron transport system to produce water with the release of ATP

5. Oxidative phosphorylation

- During the oxidative phosphorylation, $NADH_2$ generated in glycolysis, kreb's cycle and oxidative decarboxylation is oxidized to produce ATPs with the release of H_2O

OXIDATIVE DECARBOXYLATION

- It is a process of oxidation where pyruvic acid is converted into acetyl co-enzyme A (Acetyl CoA)
- Pyruvic acid is formed from glucose through glycolysis
- With the help of pyruvic acid dehydrogenase enzyme, pyruvic acid undergoes decarboxylation and oxidation
- During decarboxylation CO_2 is removed and during oxidation two hydrogen atoms are removed from pyruvic acid
- As a result pyruvic acid is converted into acetyl CoA

Pyruvic acid + CoA $\longrightarrow$ **Acetyl CoA + CO_2 + H_2**

- During this process two hydrogen atoms are released
- The two hydrogen atoms are accepted by NAD and the NAD becomes reduced to $NADH_2$

$$\mathbf{NAD + H_2 \longrightarrow NADH_2}$$

- The $NADH_2$ enters the electron transport system and it is oxidised

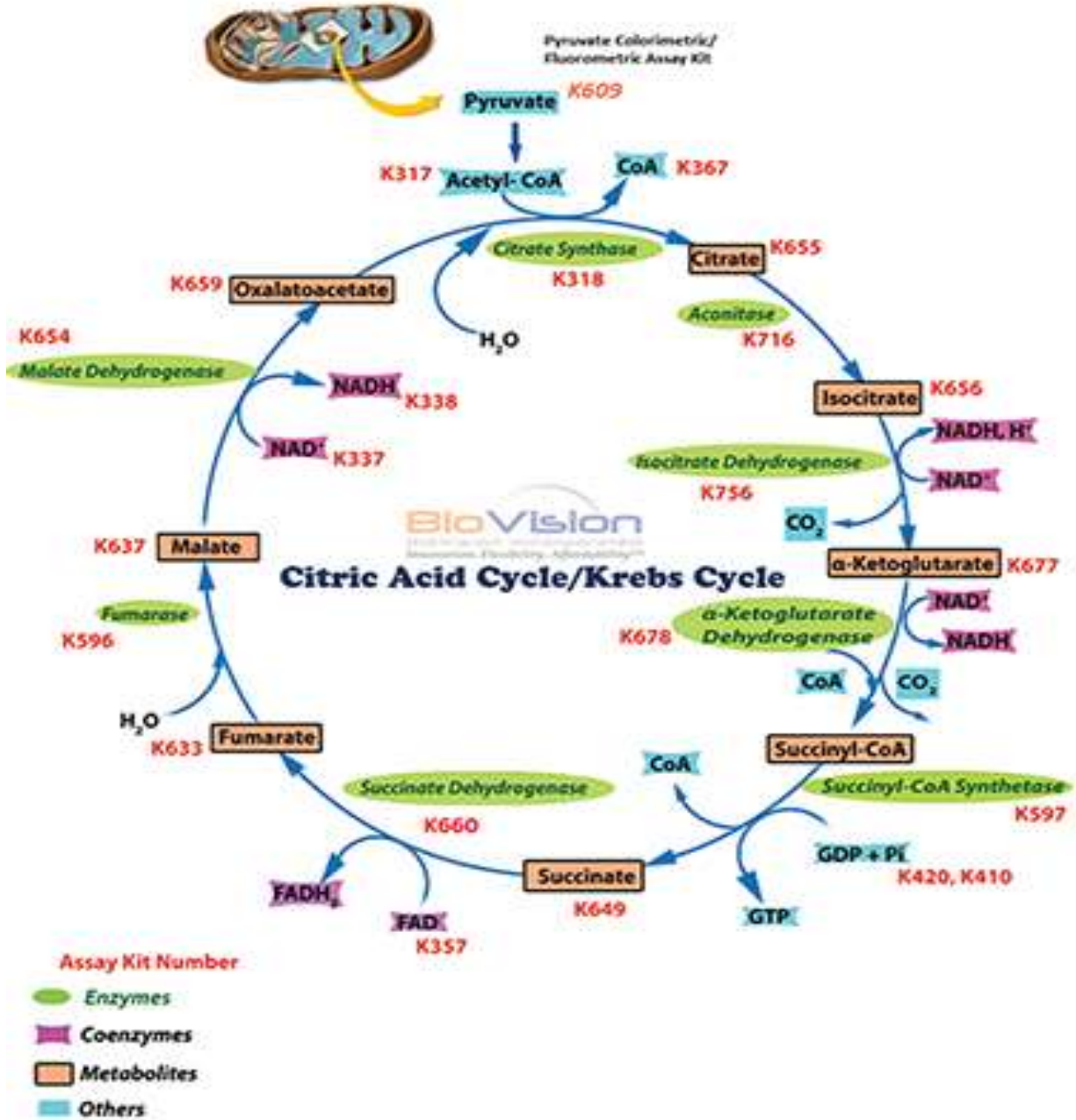
KREB'S CYCLE

KREB'S CYCLE

- The oxidation of pyruvic acid into CO_2 and water is called Kreb's cycle
- This cycle is also called citric acid cycle, because the cycle begins with the formation of citric acid
- This cycle was first described by Kreb in 1936
- This cycle occurs only in the presence of oxygen
- Hence it is an aerobic process
- Kreb's cycle takes place mainly in the mitochondria

- It involves the following steps:

1. Formation of citric acid
2. Dehydration
3. Hydration
4. Dehydrogenation I
5. Decarboxylation
6. Oxidative-decarboxylation
7. Oxidation
8. Hydration
9. Dehydrogenation II


Pyruvate Colorimetric/
Fluorometric Assay Kit
K609
Pyruvate
K317
Acetyl-CoA
CoA
K367
Citrate Synthase
K318
Citrate
K655
Aconitase
K716
Isocitrate
K656
NADH, H+
Isocitrate Dehydrogenase
K756
NAD+
CO2
α-Ketoglutarate
K677
NAD+
α-Ketoglutarate
Dehydrogenase
K678
NADH
CoA
CO2
Succinyl-CoA
CoA
Succinyl-CoA Synthetase
K597
GDP + Pi
K420, K410
GTP
Succinate
K649
FADH2
FAD
K357
Succinate Dehydrogenase
K660
Fumarate
K633
H2O
Fumarase
K596
Malate
K637
Malate Dehydrogenase
K654
NADH
K338
NAD+
K337
Oxalatoacetate
K659
H2O
BioVision
Citric Acid Cycle/Krebs Cycle
Assay Kit Number
Enzymes
Coenzymes
Metabolites
Others

1. **Formation of citric acid**

- The acetyl CoA combines with oxaloacetic acid to form citric acid
- This reaction is catalyzed by an enzyme called citric acid synthetase

2. **Dehydration**

- The citric acid undergoes dehydration and forms cis-aconitic acid
- This reaction is catalyzed by the enzyme aconitase

3. **Hydration**

- The aconitic acid is hydrated and it form isocitric acid
- This reaction is catalyzed by the enzyme aconitase

4. **Dehydrogenation I**

- The isocitric acid undergoes dehydrogenation in the presence of isocitric acid dehydrogenase to form oxalosuccinic acid

5. Decarboxylation

- The oxalosuccinic acid undergoes decarboxylation to form ketoglutaric acid
- This reaction is catalyzed by decarboxylase

6. Oxidative decarboxylation

- During oxidative decarboxylation, α-keto glutaric acid is converted into succinyl CoA.
- This reaction is catalyzed by α-keto glutaric acid dehydrogenase
- In the next step, the succinyl CoA is decarboxylated to succinic acid
- This step is catalyzed by succinic acid thiokinase

7. Oxidation

- The succinic acid is oxidized to fumaric acid is catalyzed by succinic acid dehydrogenase

8. Hydration

- The fumaric acid then undergoes hydration to form malic acid is catalyzed by fumarase

9. Dehydrogenation II

- It is the final step in kreb's cycle
- Oxaloacetic acid is regenerated from malic acid by a process of dehydrogenation
- This reaction is catalyzed by malic acid dehydrogenase

The oxaloacetic acid formed in the above reaction condenses with the acetyl CoA to form citric acid again and thus the cycle is repeated