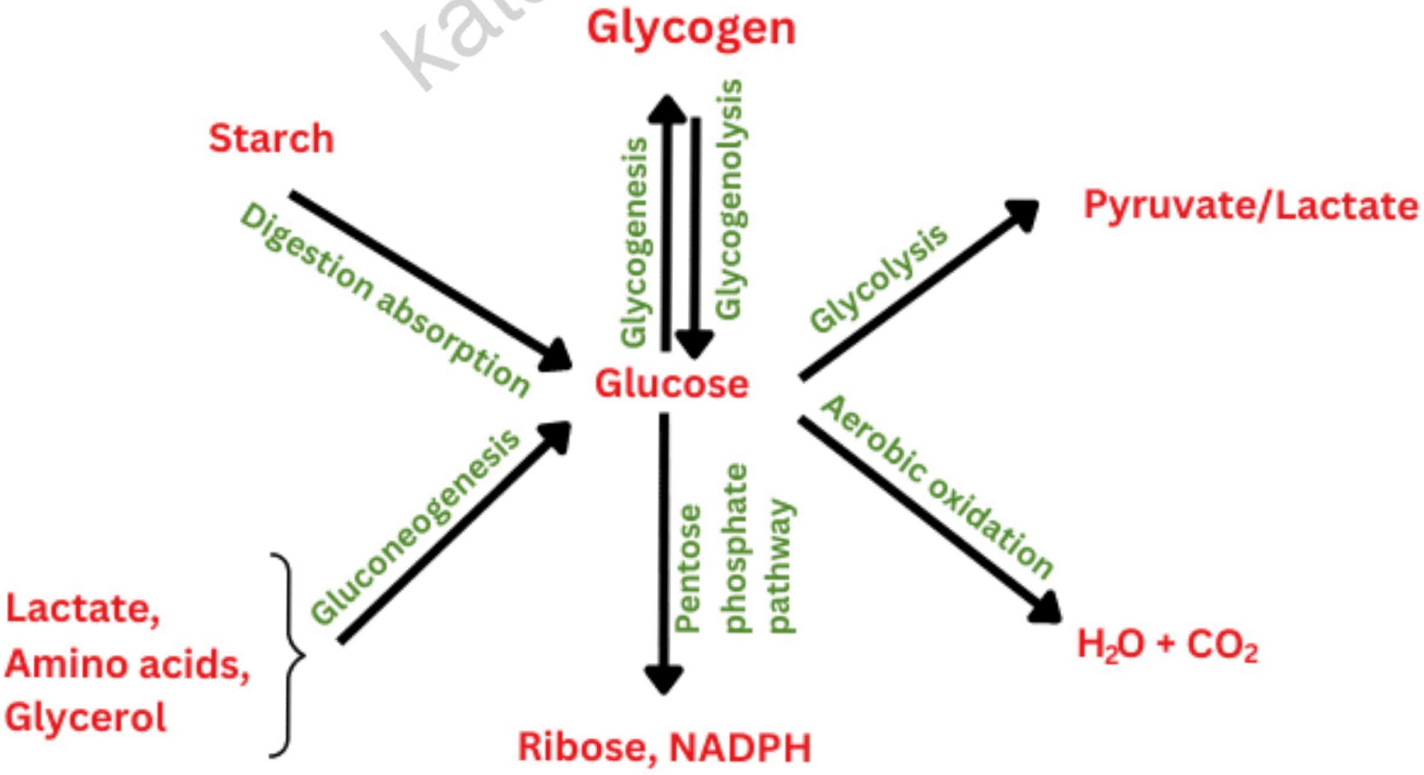
✯ Carbohydrate Metabolism :-

- Biochemical processes involves in Synthesis, breakdown and inter-conversion of Carbohydrates in living organism are collectively called as Carbohydrate Metabolism.
- Glucose is the essential molecule of Carbohydrate Metabolism which participates in various metabolic pathways
- Insulin is the primary metabolic hormone synthesised in pancreas and regulates glucose level in blood.

Carbohydrate metabolism

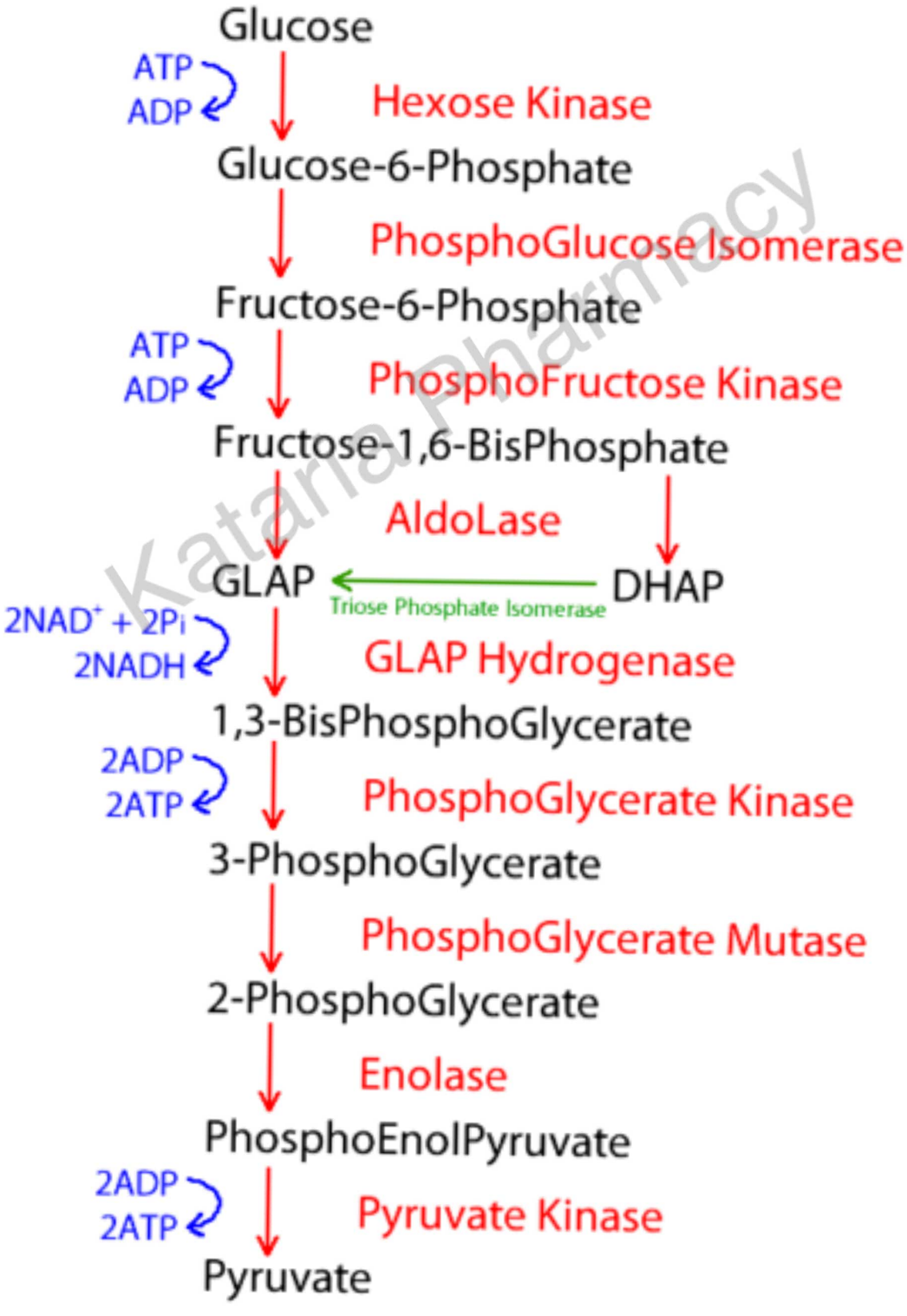


Major Pathways of Carbohydrate Metabolism :-

① Glycolysis :-

Glycolysis is an important pathways of Carbohydrate metabolism and occurs Cytosol of a living Cell.

- In glycolysis one mol glucose yield two moles of Pyruvate, ATP and NADH.



Energetics :-

- Net gain in glycolysis is 2 ATP, 2 pyruvate and 2 $NADH_2$ Molecule.
- Glycolysis is a low energy process as pyruvate, and $NADH_2$ Molecule Captures much of the energy.

Table: Input and output of Material during Glycolysis

Total input	Total output
1 Molecule of glucose (6C)	2 molecule of pyruvic acid (2×3C)
2 ATP	4 ATP
4 ADP	2 ADP
2 × NAD	2 × $NADH_2$
2 × P_i	2 × H_2O

- Total 8 ATP generate during one Cycle of glycolysis.

Significance :-

① In glycolysis pathway, glucose is oxidised to yield pyruvate

② Enzyme involve in glycolysis pathway are present in Cytosol of a cell.

③ All Cell Utilise glucose for energy

④ In a Single pathway of glycolysis two molecule of ATP and NADH are generated.

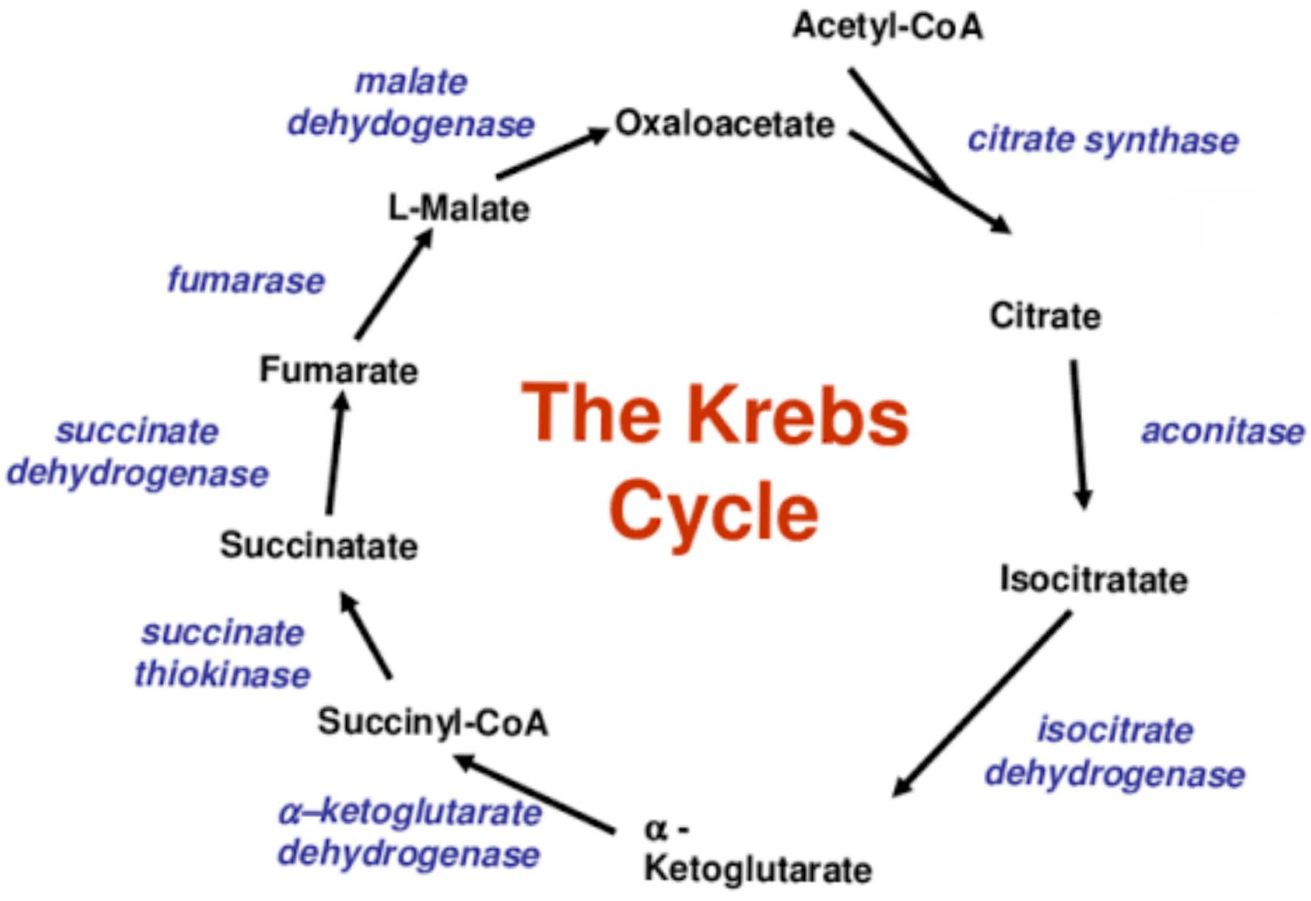
⑤ Energy produce by anaerobic glycolysis provides reduce oxygen Supply in cell.

⑥ Regulation of glycolysis is important to maintain ATP balance.

② Citric acid Cycle :-

- The citric acid Cycle (krebs Cycle or tricarboxylic acid - TCA Cycle) is the most important Metabolic pathway for the energy Supply to the body.
- ATP is Synthesized in krebs Cycle. citric acid Cycle essentially involves the oxidation of acetyl CoA to Co_2 and H_2O.

Pathway



- Once pyruvate undergoes oxidative decarboxylation to form acetyl CoA, they acety CoA then enter the citric acid Cycle, also known as the krebs Cycle.
- The citric acid Cycle is a series of eight reaction that ~~track~~ break down acetyl CoA, the product of pyruvate decarboxylation, to yeild high-energy electron-Carrier molecules such as NADH and $FADH_2$
- The purpose of the citric acid Cycle is to harvest the "high energy" electron from the Carbon fuel Source the ultimately Come from glucose.

Step 1: Oxaloacetate and acetyl CoA react to form citryl CoA, which then react with water to form citrate. The purpose of this step is to create a molecule that will ultimately undergo decarboxylation.

Step 2: The hydroxyl group on citrate is not positioned correctly to undergo a decarboxylation, therfore citrate is transformed into isocitrate by an enzyme called aconitase.

Step 3: This is the first oxidation-reduction reaction Creation of the citric acid Cycle, Hence we first reduce NAD^+ into NADH and then produce the α-ketoglutrate via an oxidative decarboxylation reaction.

Step 4:- This is the Second oxidative decarboxylation reaction we form a four-Carbon Molecule, releasing Co_2 and forming NADH

Step 5 :- In this step, we transfer a phosphate group from Succinyl CoA into a GDP to form GTP. This is the only step in the citric acid cycle that produces with a high phosphoryl transfer potential.

Step 6-8 :- The final three step of citric cycle involve the regeneration of the oxaloacetate Molecule.

- In this process of the regeneration of oxaloacetate, also form $FADH_2$ (step 6), NADH (step 8) and use water (step 7)

Product = 4 CO_2, 6 NADH, 2 $FADH_2$, 2 GTP, 4 H^+, 2 CoA.

(3) Hmp Shunt :-

- Hmp (Hexose mono phosphate) Shunt is also known as pentose phosphate pathway.
- It is an alternative pathway for glucose oxidation and is a Multi-cycle process.
- Enzyme of Hmp shunt are located in Cytosol.

#pathway :-

Reaction of the pathway -

Reaction of Hmp pathway is divided into Two phases.

1. oxidative phase
2. Non-oxidative phase

1. oxidative phase :-

Step-1 :- Glucose-6-Phosphate Convert into 6-phospho gluconolactone in presence of enzyme Glucose-6-phosphate dehydrogenase. (Rate limiting step)

Step 2 : 6-phosphogluccolactone Convert into 6-phosphogluconate in presence of enzyme Gluconolactone hydrolase.

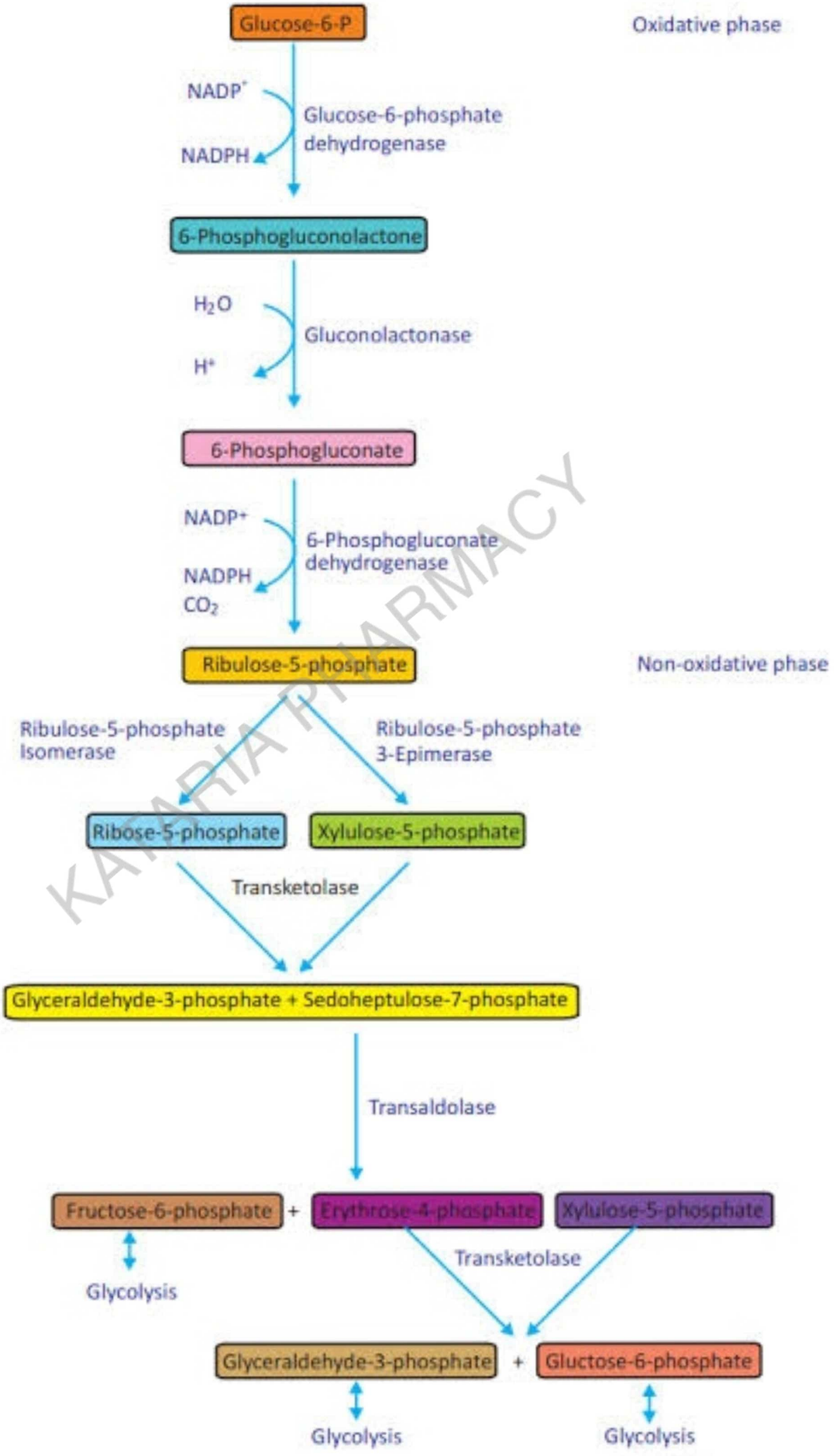
Step 3 : NADPH is agin generated.

6-phosphogluconate Convert into Ribulose-5 phosphate in presence of enzyme 6-phosphogluconate dehydrogenase and 6-Molecule of Co_2 is released.

② Non-oxidative phase :-

Step 4 :- Termination -

Ribulose-5-phosphate Convert in → (epimerase) xylulose-5-phosphate
→ (Isomerase) Ribulose-5 phosphate



Step 5 :- Transketolase Reaction

Step 6 :- Transaldolase Reaction -

Sedoheptulose-7-phosphate and Glyceraldehyde-3-phosphate Convert into Erythrose-4-phosphate and fructose-6-phosphate in presence of enzyme Transaldolase.

Significance :-

- Free radical Seavenging
  - The free radicals (super oxide, hydrogen peroxide) are Continuosly produce in all Cells.
- Hmp Shunt is unique in generating two important product - pentose and NADPH
- NADPH is required for the bio Synthesis of fatty acids and Steroids.
- NADPH is required by the RBC to keep the glutathione in the reduced state.

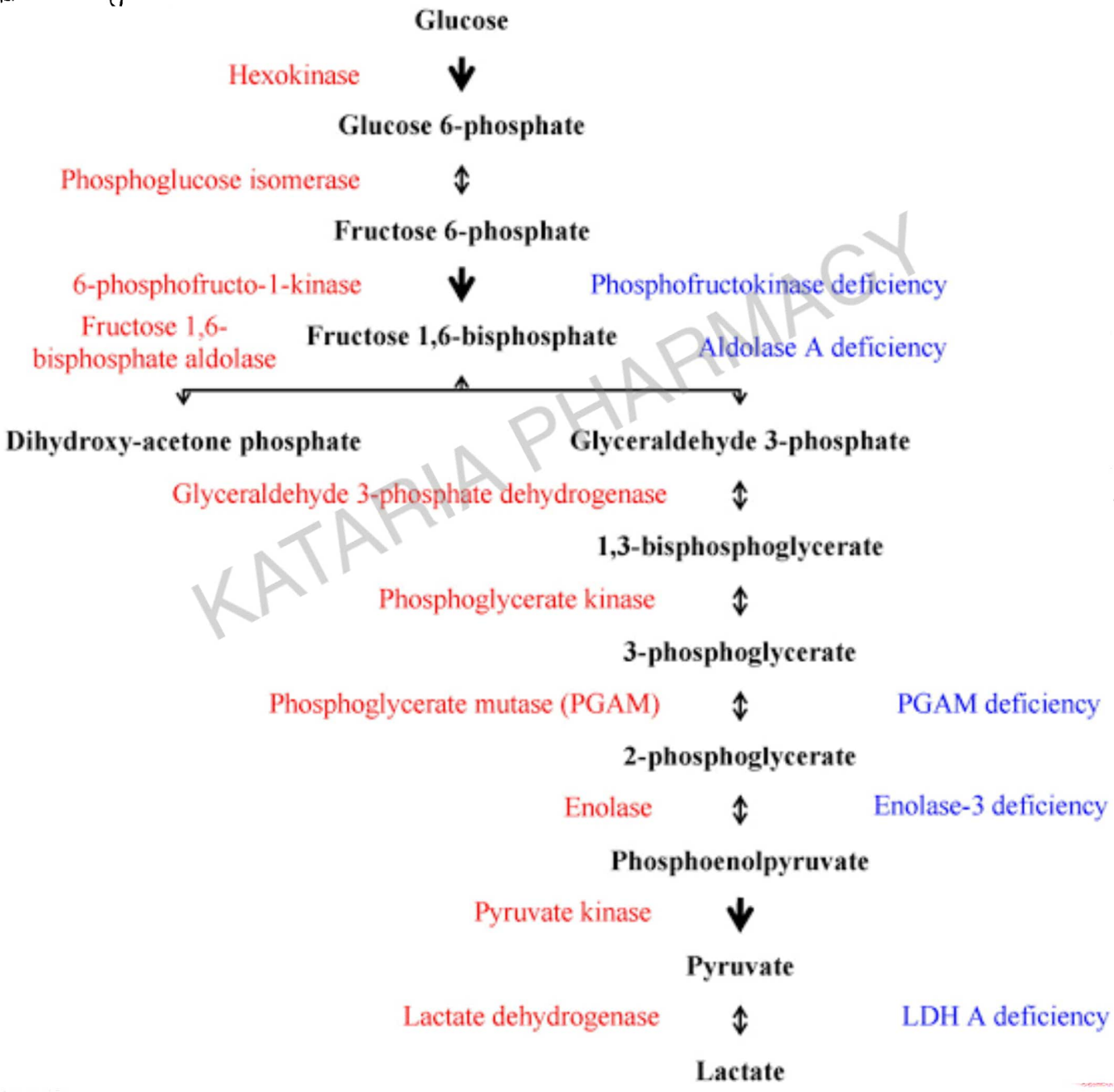
☆ Glycogen Metabolism pathways :-

- In animals, glucose is stored in the form of glycogen.
- Glycogen is stored in the form of granules in cell cytosol where most of the enzyme required for the synthesis and breakdown are found.

Glycogenesis :-

Glycogenesis is glycogen synthesis from glucose. This occurs in cytosol with the help of Adenosine Triphosphate and ~~Triphosph~~ Uridine triphosphate.

pathway



☆ Glycogen Storage Disease (GSD) :-

- Glycogen Storage disease are genetic disorder of glycogen Metabolism occuring due to accumulation of Large amount of glycogen or its Metabolites into the tissue.
- Glycogen accumulates in the absence of glycogen metabolising enzyme. Not all but few of the disorder are serious
- Glycogen Storage diseases are as follows.

① Von Gierke's Disease :-

This disease is related to the deficiency or Complete absence of enzyme glucose-6-phosphate in liver, kidney and intestine.

② Pompe's Disease :

It is a fatal disease arising due to decrease in lysosomal α-glucosidase, thus glycogen is not utilised by lysosomes and accumulates in body tissue.

③ Anderson's disease :-

In this disease, an intermediate product of glycogenesis amylopectin deposits in the liver, spleen and heart.

④ Other :- ① Cori's disease
② Mc Ardle' Syndrom
③ Hers Disease

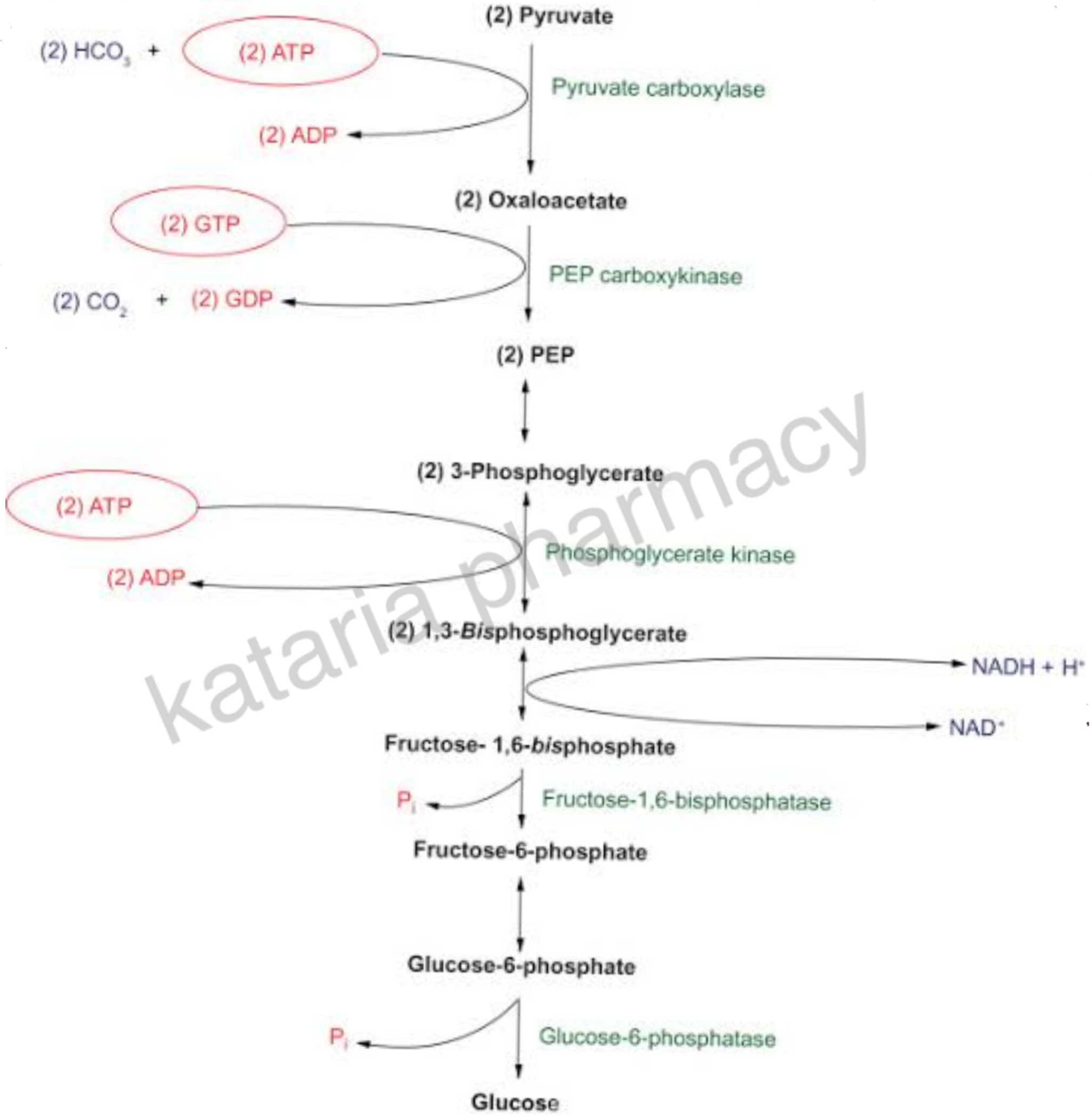
] Search about on Google

Gluconeogenesis :-

- Gluconeogenesis is a metabolic pathway which includes the biochemistry reaction Synthesising glucose from any non-Carbohydrate Source Such glycerol, pyravate, lactate. and glucogenic amino acids.
- Most of the reactions of gluconeogenesis take place in the liver and few of the reaction in the Cortex part of kidney.

Pathway :-

Gluconeogenesis is almost the reversible pathway of glycolysis (Pyruvate Converted to glucose) but not the exact reversal of glycolysis.



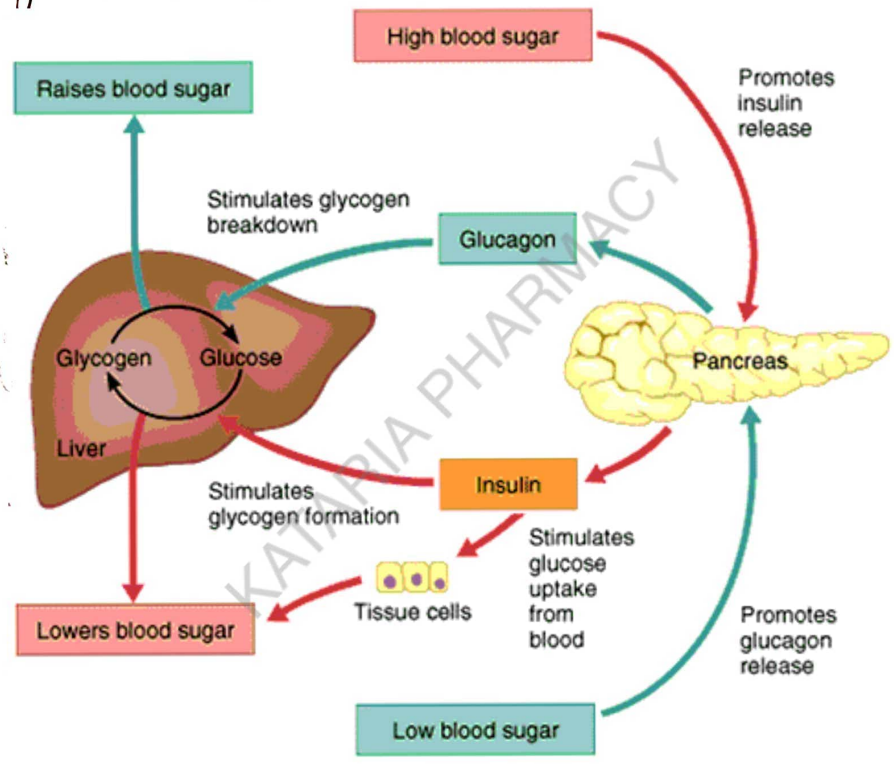
Significance of gluconeogenesis :-

- Gluconeogenesis meets the needs of the body for glucose & maintains glucose homeostasis in absence of Carbohydrate.
- Some tissue such as the brain, RBCs, Lens, Cornea & kidney Medulla requires Continous Supply of energy.
- It is used to clear the products of the Metabolism of other tissue from the blood e.g. Lactate, Glycerol.
- To Maintain amount of glucose.
- Removal of glycerol producted by Lipolysis.

✱ Hormonal Regulation of Blood Glucose Level :-

There are two Categories of endocrine influences.

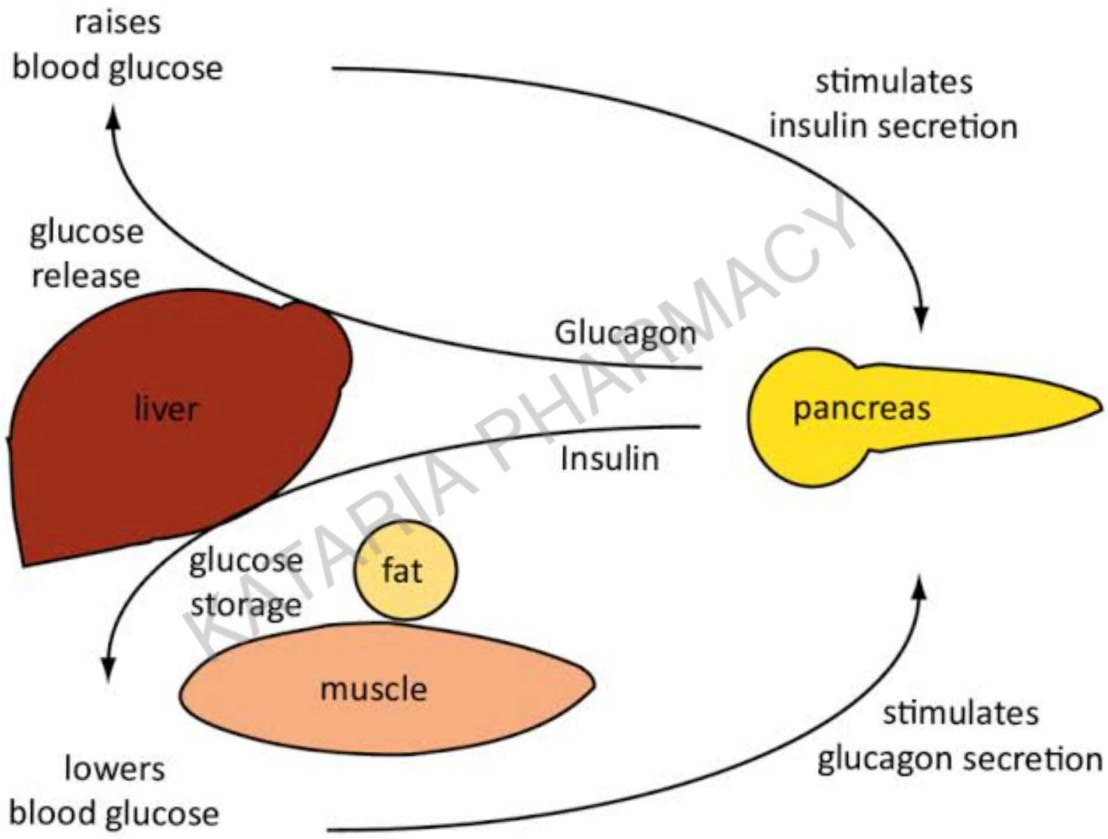
1. Hormone which will decrease the blood glucose levels
   Eg. Insulin
2. Hormones which will Increase the blood glucose levels:
   eg. Glucagon, Epinephrine, Cortisol and Glucocorticoids.



11 Insulin & Glucagon :-

Both of these hormones are Secreted by endocrine tissue of pancreas known as Islet Cells or Islets of Langerhans.

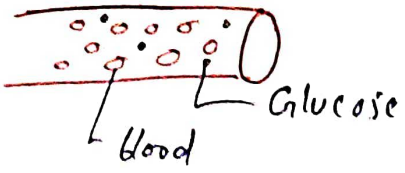
- Each Islet Contains two kinds of Cells:
  1. α-Cells (secrete glucagon) ——— ↑ Blood glucose Level.
  2. β-Cells (secrete insulin) ——— ↓ Blood glucose Level



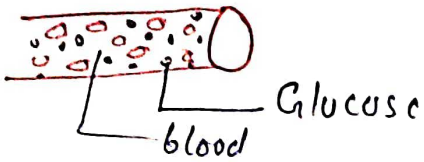
✱ Diabetes Mellitus :-

Diabetes Mellitus is a Metabolic disorder in which a person has high blood Sugar, either because the body does not produce enough insulin.

Normal Blood glucose level



High blood glucose



Types of DM :-

① Type I DM :-

This type is characterised by destruction of β-cell (insulin producing cell) and thus insulin is required for survival.

- Effects children
- Genetic variations & auto-immune response are leading cause.

② Type II DM :-

This type is characterised by disorder of insulin action or insulin secretion. patient have relative insulin deficiency

- It is also known as adult onset diabetes.

Causes of DM :-

① Genetic factors → Genetic defect in β-cell function
→ Genetic defects in insulin action.

② Environmental factor → obesity associated with modern living.
→ Lifestyle change (consumption of alcohol)

Symptoms of DM :-

① Increase thirst
② Slow healing cuts and sores
③ Fatique
④ Blurred vision.
⑤ Frequent urination.
⑥ Unexplained weight loss.

✱ Biological oxidation :-

- In chemical terms, removal of electrons is ~~as~~ termed as oxidation and addition of a electrons is termed as Reduction.
- Thus, oxidation always goes with reduction of an electron acceptor.
- This phenomenon of oxidation-reduction also applies in biochemical System and describe biological oxidation in a living System.
- In cell during respiration, biological oxidation takes place in four stages, Carbohydrate (glucose) is used as a Source of energy.

1. Glycolysis : It is the first stage in which glucose degrades into pyruvate.

2. Oxidative Decarboxylation of pyruvate :
   This stage occurs for a short term in which a 2-C Containing Molecule is formed from the 3-C Containing Molecule, pyruvate with the release of CO_2.

3. Citric acid Cycle :-
   In this stage, the 2-C Containing Molecule is degraded into CO_2.

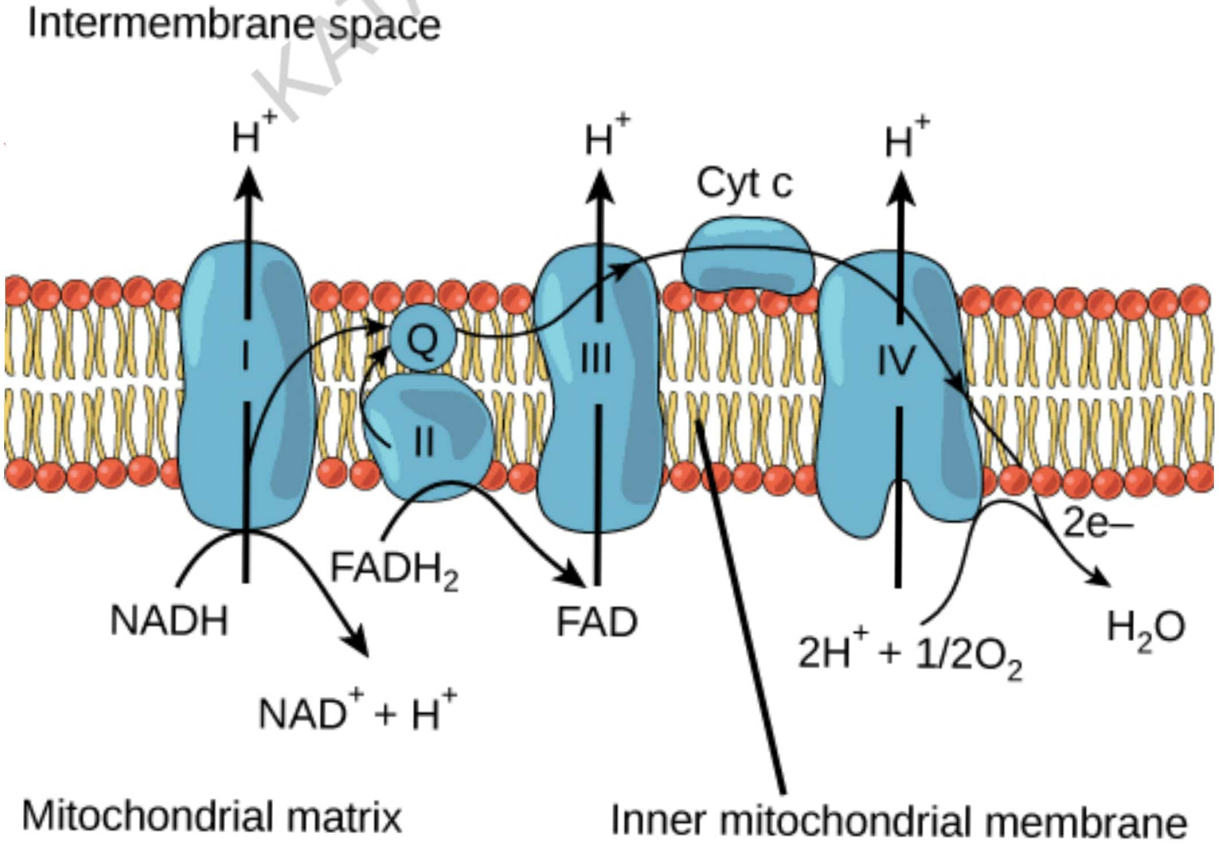
* Electron transport Chain (ETC) :-

ETC Couple a chemical reaction blw an electron doner and electron acceptor to the transfer of H^+ ions across a membrane, through a set of mediating biochemical reaction.

- These H^+ ions are used to produce ATP.
- In ETC, the electron travel through the chain, passing from a higher to a low energy level by moving through electron-rich to electron-deficit Molecule.

ETC Components :-

- 5 protein Complexes - I, II, III, IV, V
- Coenzyme Q
- Cytochrome c - a peripheral membrane protein.



Mechnism of ETC :-

The steps involved in electron transport Chain are.

① The hydrogen Carriers from the citric acid Cycle enter the inner Mitochondrial Membrane folds knows as Cristae.

② In the Cristae, the H^+ Ions are oxidised by a Series of step using Molecular oxygen to release energy.

③ A part of this energy is utilised in oxidative phosphorylation in which ATP (from ADP) and inorganic phosphate are produced.

④ H^+ Ions or electron moves downhill i.e from a higher energy level to lowes energy levels by passing from one Carrier to the next, until they reach the oxygen.

⑤ The oxygen accepts electrons and reduces to form water.

⑥ At each transfer level, Some amount of energy is released in the form of heat which is utilised for producing ATP.

Significance :-

① Regenerating Electron Carrier

② Cenerating proton Gradien.

✱ Oxidative phosphorylation :-

- ~~Oxi~~ Oxidative phosphorylation is electron transport chain or Chemiosmosis.
- It is a process in which ATP is formed as a result of transfer of electrons from NADH or FADH2 to O_2 by series of electron Carriers.

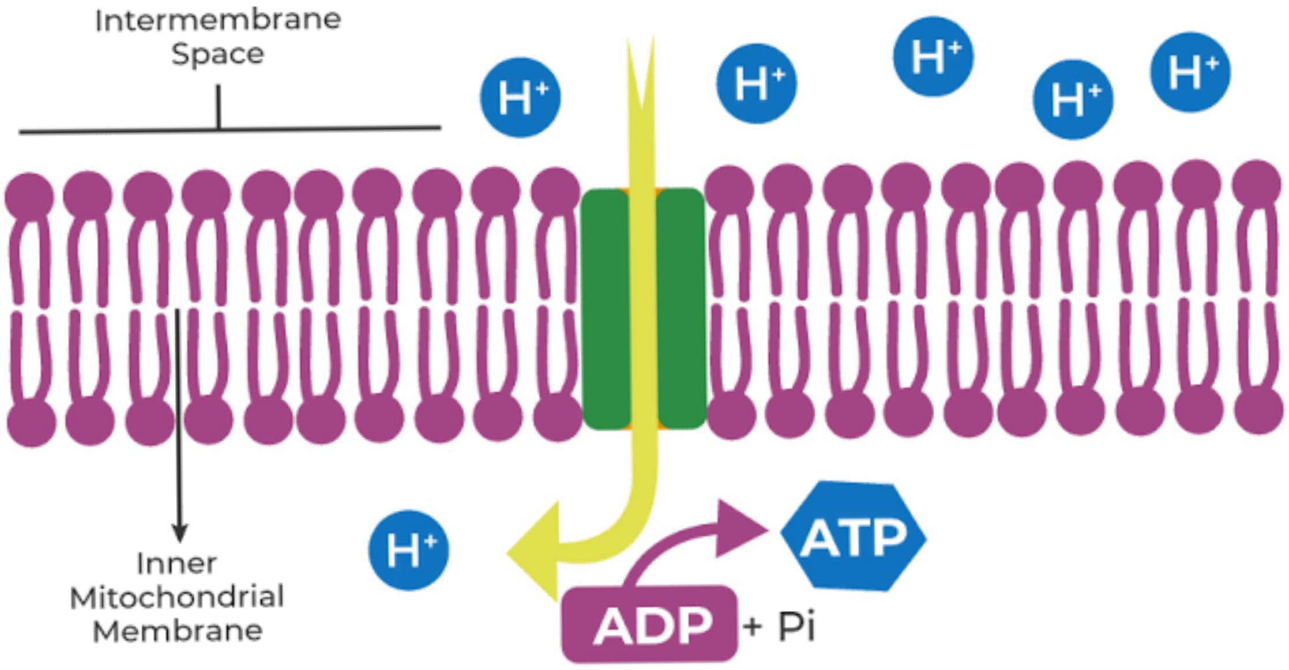
A. Oxidation step : Electron transport Chain

$$NADH + H^+ + O_2 \longrightarrow NAD^+ + H_2O$$

$$FADH_2 + O_2 \longrightarrow FAD + H_2O$$

B. Phosphorylation step:

$$ADP + Pi \longrightarrow ATP$$



✡ Inhibitors of oxidative phosphorylation / uncoupler:-

- Electron transport within mitochondria and oxidative phosphorylation (ATP Synthesis) are combind process.
- It is also be said that oxidation and phosphorylation process proceed simultaneously.
- Some compound have ability to uncouple these two reactions. and such compounds are known as ~~Uncop~~ uncouplers.
- The uncouplers increase permeability of the inner mitochondrial membrane towards protons (H^+) and thus inhibiting ATP formation.
- The energy generated during electron transport is dissipated in the form of heat.
- Thus, the uncouplers facilitate oxidation of substrates without ATP Generation.

THANK YOU