Difference Between Glycolysis and TCA Cycle

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Glycolysis vs TCA Cycle

Respiration is a process which occupies a series of reactions which are coupled by oxidation and reduction reactions and electron transfer. At the end of the respiration, organisms produce energy to utilize for their metabolic processes. This energy is produced in the form of ATP (energy currency of the cells). During aerobic respiration, oxygen molecules act as the final electron acceptors and are reduced to produce water. This creates an electrochemical gradient which drives the ATP synthesis. Aerobic respiration consists of three main phases, where carbon molecules are rearranged through a series of enzyme catalyzed reactions to yield ATP. The first phase, common to both aerobes and anaerobes, is the glycolytic pathway where sugar substrate, mainly glucose, is catabolized to two pyruvate molecules. This conversion produces two ATP molecules and two NADH molecules. The second phase is the tricarboxylic acid (TCA) cycle, which is the central hub where intermediates of all metabolic pathways join to contribute towards energy production by producing NADH, FADH2 and two molecules of CO_2 via oxidation-reduction reactions. The TCA cycle only takes place in aerobes. In both these processes, substrate level phosphorylation takes place to produce energy. The key difference between glycolysis and TCA cycle is that **glycolysis occurs in the cytoplasm while the TCA cycle occurs in mitochondria.**

What is Glycolysis?

Glycolysis or the **Embden-Meyerhof Pathway** is the first step of energy production and takes place in the cytosol of both aerobes and anaerobes. It is an enzyme catalyzed reaction procedure comprising of ten reaction steps. In glycolysis, sugar molecules are phosphorylated and trapped in the cell to catabolize into two pyruvate molecules (three carbon compound) which are the end products of glycolysis.

It has three main stages as follows:

Preparatory Stage

In this stage, sugar residues which contain six carbon atoms are phosphorylated and trapped in the cell. Preparatory phase is an energy requiring phase where two ATP molecules are utilized.

Cleavage Stage

During this phase, the 6-carbon molecule is cleaved into two phosphorylated 3-carbon residues.

Pay off Stage

This is the final stage of glycolysis where ATP and NADH are synthesized. For each 6 carbon sugar substrate, 4 ATP molecules, 2 NADH molecules, and 2 Pyruvate molecules are produced; thus it is the energy producing phase of glycolysis.

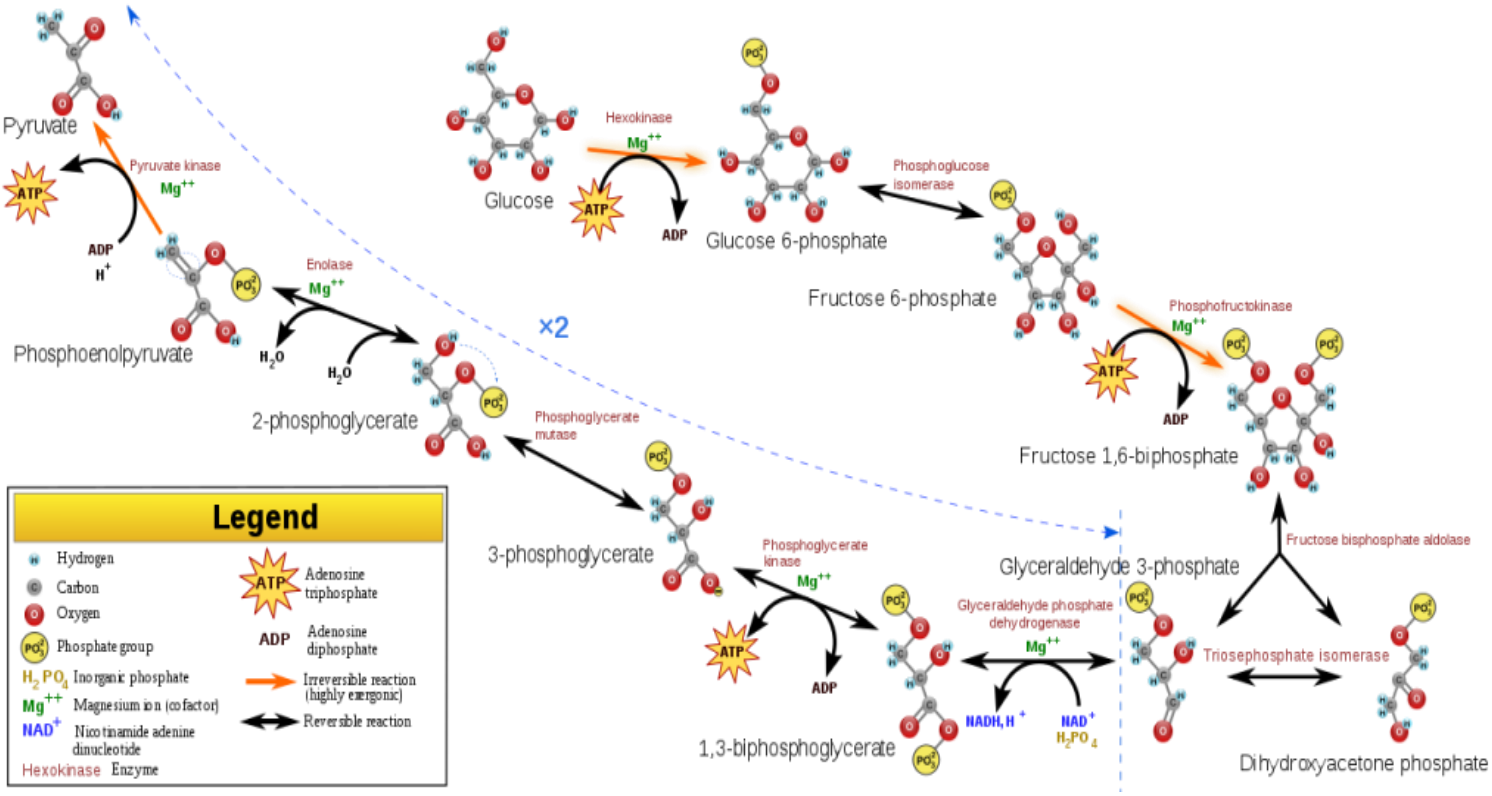

Figure 01: Glycolysis

Overall Reaction of Glycolysis

$$Glucose + 2P_i + 4ADP + 2NAD^+ + 2ATP \rightarrow 2Pyruvate + 4ATP + 2NADH + 2H_2O + 2H^+$$

Net production of ATP = 2ATP

What is TCA Cycle?

TCA cycle, also referred as **Citric acid cycle** or **Krebs cycle**, takes place in the matrix of mitochondria. It is a part of aerobic respiration; hence it takes place only in aerobes. TCA cycle is a cyclic, enzyme catalyzed pathway where a 4-carbon substrate (oxaloacetic acid) accepts 2-carbon Acetyl CoA to yield a 6-carbon molecule (citrate). Citrate undergoes a cyclic metabolic pathway to produce two carbon dioxide molecules, two NADH molecules, one $FADH_2$ molecule and one GTP molecule. The primary function of the TCA cycle is to harvest high energy electrons from carbon fuels. These high energy electrons are then transferred to the electron transport chain, which is the final stage of aerobic respiration for the synthesis of ATP. TCA cycle also acts as the final common pathway for the oxidation of carbohydrates, amino acids, fatty acids, and nucleotides. Carbohydrates and fatty acids enter the TCA cycle as Acetyl Coenzyme A whereas amino acids enter the TCA cycle as α – ketoglutarate and nucleotides as fumarate.

Overall Reaction of TCA Cycle

$$\text{Acetyl Co A} + 3\,NAD^+ + FAD + GDP + 2P_i + 2H_2O \rightarrow 2CO_2 + 3NADH + FADH_2 + GTP + 3H^+$$

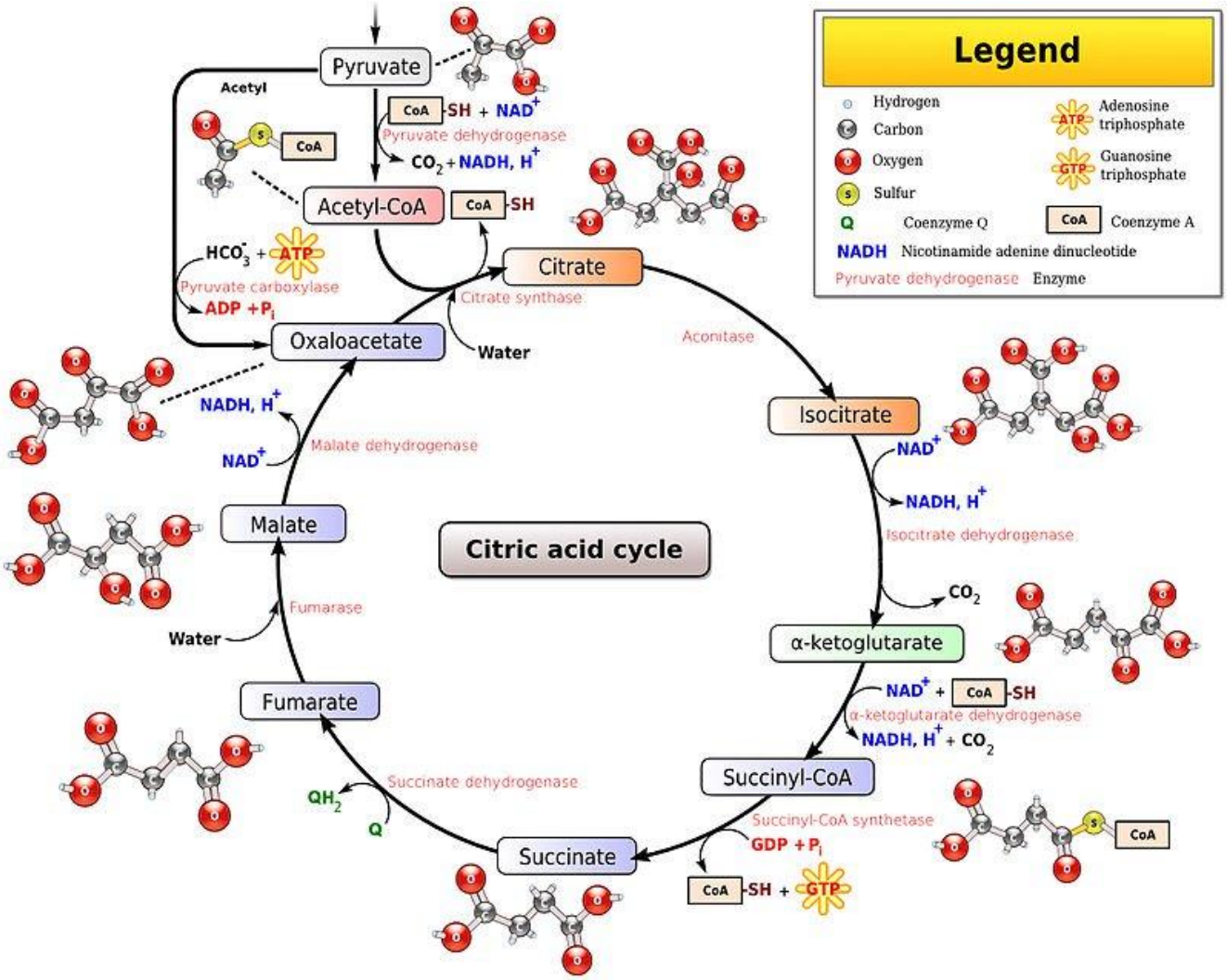

Figure 02: TCA Cycle

What are the similarities between Glycolysis and TCA cycle?

- Glycolysis and TCA cycle comprise of series of enzyme catalyzed reactions.
- In both processes, substrate level phosphorylation takes place.
- Both processes produce NADH, H_2O as products.
- Both processes are regulated through hormonal control, allosteric regulation and end product inhibition (feedback mechanisms).

What is the difference between Glycolysis and TCA Cycle?

Glycolysis vs TCA Cycle	
Glycolysis is the process where 6 carbon sugar (monosaccharide) molecules are catabolized into 3- carbon pyruvate	TCA cycle is the process where the energy stored in carbon molecules are harvested to produce electron-rich compounds for electron

molecules through enzyme catalyzed reactions.	transport chain to synthesize ATP via oxidative phosphorylation.
Site of Reaction	
Glycolysis occurs in the cytosol.	TCA cycle occurs in the matrix of mitochondria.
Requirement of Oxygen	
Glycolysis can occur under both aerobic and anaerobic conditions.	TCA cycle is strictly aerobic.
Starting Compound	
Six carbon monosaccharide (glucose) is the starting substrate of glycolysis.	Four carbon Oxaloacetate is the starting substrate of TCA cycle.
End Products	
Two Pyruvate molecules, two ATP molecules, and two NADH molecules are the end products of glycolysis.	Two CO2, one GTP, three NADH and one FADH2 are the end products of TCA cycle.
Sequence of Reactions	
Glycolytic reactions occur as a linear sequence.	TCA cycle occurs via a cyclic sequence.
Involvement of CO_2	
CO2 is not required or produced during the glycolysis.	CO2 is produced for each acetyl co A molecule of TCA cycle.
Consumption of ATP	
2 ATP molecules are consumed by the glycolytic pathway.	ATP molecules are not utilized in TCA cycle.

Summary – Glycolysis vs TCA Cycle

Glycolysis and TCA cycle are two vital metabolic pathways involved in the production of energy via carbon intermediates derived from the macro molecules carbohydrates, proteins, fats and nucleic acids. Both processes are enzyme mediated and are under constant regulation based on the energy requirement of the cell/organism and the rates of these processes differ under various conditions such as the fasting state, well-fed state, starvation state and exercised state. It is important to study the regulation of the glycolytic pathway and the TCA cycle in order to derive biochemical relationships to address metabolic imbalances in the body. Glycolysis is the initiative process of respiration and TCA cycle is the second major phase of aerobic respiration which connects with the final stage of the respiration (electron transport chain). Glycolysis occurs in the cytoplasm and produces pyruvates; these pyruvates enter the mitochondria and aid in TCA cycle. Glycolysis can happen under both aerobic and anaerobic organisms. However, TCA cycle happens only in aerobic organisms since it needs aerobic conditions. This is the difference between glycolysis and TCA cycle.

References:

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