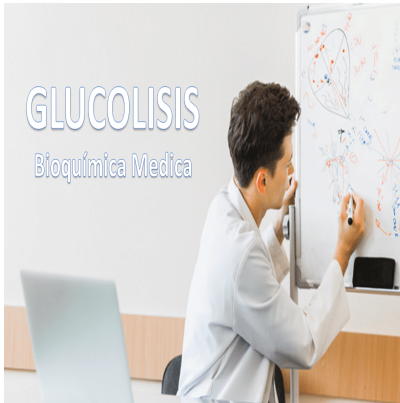




Glycolysis

Description

Glucose is the fuel par excellence of most cells in the human body. It is from glucose that the different cells of the body can generate Adenosine Triphosphate (ATP). This process is called Glycolysis.

What is glycolysis?

Glycolysis is an oxidative process. Where a glucose molecule becomes Pyruvate.

This metabolic process has the main objective the formation of ATP. This metabolic pathway works both in the presence of oxygen or without oxygen.

The glycolysis pathway

Glycolysis has a total of 10 enzymatic chain reactions. Which are divided into 2 phases. This is known as the Glycolysis pathway.

Energy requiring phase

The first step in this metabolic pathway is the phosphorylation of glucose to glucose-6-phosphate. This step catalyzed by the enzyme Hexokinase. This process uses an ATP molecule to transfer the phosphate group. **The first ATP molecule from glycolysis is used.**

Glucose-6-phosphate is related to several metabolic pathways. Among these are Glycolysis, Gluconeogenesis, Glycogenolysis, Glycolysis and the pentose phosphate pathway.

In Glycolysis, **glucose-6-phosphate is converted to fructose-6-phosphate** by the enzyme **phosphohexose isomerase**. This reaction is an aldose-ketosis isomerization.

Isomerization is when a molecule is transformed into another that has the same number of atoms, but arranged or ordered differently.

Fructose-6-phosphate is then phosphorylated by the enzyme **phosphofructokinase**. Becoming **1,6-bisphosphate**. In this reaction, it is an ATP molecule that donates the phosphate group. So **the second ATP molecule of Glycolysis is used up**.

Fructose 1,6-bisphosphate is catalyzed by the enzyme **aldose**. Which divides the molecule in 2, generating **Glyceraldehyde-3-phosphate** and **Dihydroxyacetone phosphate** (also known as Glycerone phosphate).

The **Dihydroxyacetone phosphate** molecule is catalyzed by the enzyme **triose phosphate isomerase**. Becoming **Glyceraldehyde-3-phosphate**. So from this step there are 2 glyceraldehyde-3-phosphate molecules in Glycolysis

Energy releasing phase

Glyceraldehyde-3-phosphate is then oxidized by the enzyme **glyceraldehyde 3-phosphate dehydrogenase** to **1,3-bisphosphoglycerate** (also called just **Dysphoglycerate**). This reaction is dependent on NAD and therefore **NADH is produced**.

The following reaction converts **1,3 bisphosphoglycerate** to **3-phosphoglycerate**. The enzyme in charge of this process is **Phosphoglycerate kinase**. This is a transferase enzyme. In other words, it catalyzes the transfer of a phosphate group to an ADP molecule, **generating ATP**.

For each molecule of Glucose, two molecules of Triose Phosphate are produced (Glyceraldehyde-3-phosphate and Dihydroxyacetone phosphate), which means that 2 ATP molecules are also produced in this reaction.

The **3-Phosphoglycerate** is then converted to **2-Phosphoglycerate** by the enzyme **Phosphoglycerate mutase**. This enzyme internally transfers the phosphate group from carbon 3 to carbon 2.

The **2-Phosphoglycerate** is then dehydrated by the enzyme **Enolase** (Also called **Phosphopyruvate Hydratase**). What gives rise to **Phosphoenolpyruvate**.

Phosphoenolpyruvate is then dephosphorylated by transferring its phosphate group to an ADP molecule. Creating a molecule of ATP. As in the previous case, **for each glucose molecule 2 Pyruvate molecules are formed**. So 2 molecules of ATP are actually created.

This reaction is catalyzed by the enzyme **Pyruvate Kinase**. **Pyruvate is then the end product of the glycolysis pathway**.

The Pyruvate can then continue to the Krebs Cycle if oxygen is available. In the absence of oxygen it will become Lactate.

At the end of the Glycolysis Pathway, a total of 4 ATP is produced (2 ATP in the formation of Triose Phosphate and 2 ATP in the synthesis of Pyruvate)

Aerobic and Anaerobic Glycolysis

In the presence of oxygen the pathway will be through the Citric Acid Cycle and the subsequent respiratory chain. The 2 NADH formed in the cytosol will pass through the malate-aspartate shuttle or the glycerol 3-phosphate shuttle into the mitochondria. This process is called Aerobic Glycolysis.

In the absence of oxygen, the 2 NADH must be oxidized by reducing Pyruvate to Lactate. What is known as Anaerobic Glycolysis.

In anaerobic glycolysis, the oxidation of NADH through the enzyme Lactate dehydrogenase allows the entry of a new glucose molecule into the pathway. However, in comparison, ATP production is lower

Aerobic glycolysis produces 36 ATP at the end of the respiratory chain. Anaerobic glycolysis produces only 2 ATP.

One of the main problems of anaerobic glycolysis is the formation of Lactate. Which can cause lactic acidosis. So anaerobic glycolysis is not a viable long-term option for cells.

However, it is imperative to mention that there are cells whose glycolysis will always end in Lactate. The best example of this is Erythrocytes. Let us remember that Erythrocytes lack Mitochondria and that oxidative processes from Pyruvate occur in Mitochondria.

Main reactions of Glycolysis

The 3 reactions considered irreversible in glycolysis are: **Hexokinase, Phosphofructokinase and Pyruvate Kinase.**

These reactions are not truly irreversible. In Gluconeogenesis there are enzymes capable of reversing these processes. For this reason, these reactions are considered the main ones of Glycolysis instead of irreversible reactions.

The Fructose pathway

Fructose is the second most common type of sugar. Its degradation and subsequent production of ATP share several enzymes of the glycolysis pathway.

The main difference in the Fructose pathway is the start of it. Fructose can be catabolized by the Hexokinase enzyme at the muscle level, generating Fructose 6-phosphate. However, it can also be catabolized at the Hepatic level by the enzyme Fructokinase (Also called Ketohexokinase) and converted into Fructose 1-phosphate.

Fructose has a higher affinity for Fructokinase. So most of the Fructose will go on to form Fructose

1-phosphate. This process is achieved through phosphorylation. So a molecule of ATP is spent.

Fructose 1-phosphate is then catabolized by Aldose resulting in 2 molecules: Glyceraldehyde and Dihydroxyacetone phosphate. Glyceraldehyde is converted into Glyceraldehyde-3-phosphate by action of the enzyme Glyceraldehyde Kinase. And as in Glycolysis, Dihydroxyacetone phosphate is isomerized with the help of the enzyme Triphosphate Isomerase, resulting in another molecule of Glyceraldehyde-3-phosphate.

From this point on, both molecules continue the Glycolysis Pathway.

[su_box title="????? Key points of Glycolysis ?" box_color="#004cd4?"]

- Glycolysis is the metabolic process by which a glucose molecule breaks down to form ATP
- The final product of Glycolysis is Pyruvate
- ***Glycolysis produces a total of 4 ATP during the energy-producing phase and uses 2 ATP during the energy-requiring phase. 2 NADH are also produced??***
- Anaerobic Glycolysis occurs when there is no oxygen available. NADH is oxidized by the action of the enzyme Lactate dehydrogenase.

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References consulted

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- Michael Liberman et al. (2018). Trastornos hidroelectrolíticos en *Marks Bioquímica Medica Basica* España.
- David A. Bender. et al. (2016). Glucólisis y la oxidación de piruvato *Harper Bioquímica Ilustrada* España.

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Category

1. Biochemistry

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