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COURSE > B.Sc. Life Sciences

SEMESTER > III[rd]

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ASSIGNMENT

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GLYCOLYSIS

→ Glycolysis is a process by which glycogen or glucose or other sugars are converted into pyruvic acid.

→ This process occurs in the cells.

→ This process does not utilise oxygen hence glycolysis is an anaerobic process.

→ Glycolysis is also called Embden Meyerhof pathway.

→ Glycolysis is the process in glucose is broken down to produce energy. It produces two molecules of pyruvate, ATP, NADH and water. The process takes place in the cytoplasm of a cell and does not require oxygen. It occurs in both aerobic and anaerobic organisms.

→ Glycolysis is the primary step of cellular respiration, which occurs in all organisms. Glycolysis is followed by the Krebs cycle during aerobic respiration. In the absence of oxygen, the cells make small amounts of ATP as glycolysis is followed by fermentation.

→ The metabolic pathway was discovered by three German biochemists – Gustav Embden, Otto Meyerhof and Jakub Karal Parnas in the early 19th century and is known as the EMP pathway (Embden – Meyerhof – Parnas).

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REGULATION :-

The glycolysis regulation occurs in the following stages

STAGE 1

- A phosphate group is added to glucose in the cell cytoplasm, by the action of enzyme hexokinase.
- In this, a phosphate group is transferred from ATP to glucose forming glucose, 6-phosphate.

STAGE 2

Glucose-6-phosphate is isomerised into fructose-6-phosphate by the enzyme phosphoglucomutase.

STAGE 3

The other ATP molecule transfers a phosphate group to fructose-6-phosphate and converts it into fructose 1,6-biphosphate by the action of the enzyme phosphofructokinase.

STAGE 4

The enzyme aldolase converts fructose 1,6-biphosphate into glyceraldehyde 3-phosphate and dihydroxyacetone phosphate, which are isomers of each other.

STAGE 5

Triose-phosphate isomerase converts dihydroxyacetone phosphate into glyceraldehyde 3-phosphate which is the substrate in the successive step of glycolysis.

GLYCOLYSIS

$\boxed{\text{Glucose}}$

1. Hexokinase: Glucose $\xrightarrow[\text{ATP} \rightarrow \text{ADP}]{\text{Hexokinase}}$ Glucose-6-phosphate

2. PhosphoglucoIsomerase: Glucose-6-phosphate $\xrightarrow{\text{PhosphoglucoIsomerase}}$ Fructose-6-phosphate

3. PhosphofructoKinase: Fructose-6-phosphate $\xrightarrow[\text{ATP} \rightarrow \text{ADP}]{\text{PhosphofructoKinase}}$ Fructose 1,6-bisphosphate

4. Aldolase: Fructose 1,6-bisphosphate $\xrightarrow{\text{Aldolase}}$ glyceraldehyde 3-phosphate (G3P) + dehydroxyacetone phosphate (DHAP)

glyceraldehyde 3-phosphate (G3P) $\longleftrightarrow$ dehydroxyacetone phosphate (DHAP)

5. Isomerase

6. Triose Phosphate Dehydrogenase: G3P $\xrightarrow[2NAD^+ \rightarrow 2NADH + 2H^+]{}$ 1,3-bisphosphoglycerate

7. PhosphoglyceroKinase: 1,3-bisphosphoglycerate $\xrightarrow[\text{2ADP} \rightarrow \text{2ATP}]{\text{PhosphoglyceroKinase}}$ 3-phosphoglycerate

8. Phosphoglyceromutase: 3-phosphoglycerate $\xrightarrow{\text{Phosphoglyceromutase}}$ 2-phosphoglycerate

9. Enolase: 2-phosphoglycerate $\xrightarrow[\rightarrow 2H_2O]{\text{Enolase}}$ Phosphoenolpyruvate (PEP)

10. Pyruvate Kinase: Phosphoenolpyruvate (PEP) $\xrightarrow[\text{2ADP} \rightarrow \text{2ATP}]{\text{Pyruvate Kinase}}$ $\boxed{\text{Pyruvate}}$

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STEP 6

This step undergoes two reactions :-

- The enzyme glyceraldehyde 3-phosphate dehydrogenase transfers 1 hydrogen molecule from glyceraldehyde phosphate to nicotinamide adenine dinucleotide to form NADH + H^+.

- Glyceraldehyde 3-phosphate dehydrogenase adds a phosphate to the oxidised glyceraldehyde phosphate to form 1,3-bisphosphoglycerate.

STEP 7

Phosphate is transferred from 1,3 bisphosphoglycerate to ADP to form ATP with the help of phosphoglycerokinase. Thus two molecules phosphoglycerate and ATP are obtained at the end of this reaction.

STEP 8

The phosphate of both the phosphoglycerate molecules is relocated from the third to the second carbon to yield two molecules of 2-phosphoglycerate by the enzyme phosphoglyceromutase.

STEP 9

The enzyme enolase removes a water molecule from 2-phosphoglycerate to form phosphoenolpyruvate.

> STEP - 10

A phosphate from phosphoenolpyruvate is transferred to ADP to form pyruvate and ATP by the action of pyruvate kinase. Two molecules of pyruvate and ATP are obtained as the end products.

NOTE :-

- It is the process in which a glucose molecule is broken down into two molecules of pyruvate.
- The process takes place in the cytoplasm of plant and animal cells.
- Six enzymes are involved in the process.
- The end products of the reaction include 2 pyruvate, 2 ATP and 2 NADH molecules.

GLUCONEOGENESIS

It is the synthesis of new glucose from non-carbohydrate precursors providing glucose when dietary intake is lacking or is insufficient. It is also required in the regulation of acid-base balance, synthesis of carbohydrate derived structural constituents.

Gluconeogenesis works in the opposite direction of glycolysis which creates glucose from pyruvate, lactate and glucogenic amino acids. It's also known as Neoglucogenesis. It's a universal pathway found in humans, animals, plants, fungus and other living species.

Definition :-

Gluconeogenesis (GNG) is the building of novel glucose molecules in the body as compared to glucose, which is split from the prolonged storage molecule glycogen. It primarily occurs in the liver, but it can also occur in minor levels in the small intestine and kidney.

Gluconeogenesis is the reversal of glycolysis which breaks down glucose molecules into their subcomponents.

Since it requires energy, gluconeogenesis is also known as the "Endogenous glucose pathway". When the small precursor molecules combine, a high energy product like

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glucose is produced. Gluconeogenesis is a necessary cycle that produces glucose, which is used to carry out all catabolic activities and support life.

Functions :-

Human system create glucose to keep blood sugar levels in check. Because cells use glucose to create the energy component adenosine triphosphate, blood glucose levels must be maintained (ATP). When a person hasn't eaten in a while, such as during a crisis or starvation, gluconeogenesis takes place.

Since the body does not have enough carbohydrates from the food to break down into glucose during this time, it must depend on other molecules for gluconeogenesis, such as amino acids, lactate, pyruvate and glycerol. After glucose is produced in the liver by gluconeogenesis it is released into the blood, where it can be used for energy by cells in other regions of the body.

Since it requires energy input, gluconeogenesis is also known as endogenous glucose production (EGP). Because gluconeogenesis is the reverse of glycolysis, which releases a lot of energy input. However, because gluconeogenesis happens when the body is already depleted of energy, it needs workarounds to conserve energy

GLUCONEOGENESIS

11. $\boxed{\text{Glucose}}$

P_i, H_2O — Glucose 6-phosphatase

10. Glucose 6-Phosphate

Phosphohexose Isomerase

9. Fructose 6-Phosphate

P_i, H_2O — Fructose 1,6-phophatase

8. Fructose 1,6 BisPhosphate — Aldolase

7. Glyceraldhyde 3-phosphate ⇌ Dihydroxy acetone phosphate ← Glycerol

Glyceraldehyde 3-P dehydrogenose — 2NADH + H⁺ / 2NAD⁺

6. 1,3-bisphosphoglycerate

3-phosphoglycerate Kinase — ADP + Pi / ATP

5. 3-phosphoglycerate

Phosphoglycerate mutase

4. 2-phosphoglycerate

Enolase — H_2O

3. Phosphoenol pyruvate

Phosphoenol Pyruvate carboxylase — GDP / GTP

2. Oxaloacetate ← TCA cycle ← α-Keto acid

Pyruvate carboxylase — ADP + Pi / ATP

1. $\boxed{\text{Pyruvate}}$ ← Lactate

Gluconeogenesis and

REGULATION :-

1. Gluconeogenesis originates in the liver or kidney's cytoplasm or mitochondria. To make oxaloacetate, two pyruvate molecules are required to carboxylate first. This requires one ATP (energy) molecule.
2. NADH converts oxaloacetate to malate, which can then be transported out of the mitochondria.
3. Once malate leaves the mitochondria, it oxidised back to oxaloacetate.
4. The enzyme phosphoenolpyruvate carboxykinase (PEPCK) converts oxaloacetate to phosphoenolpyruvate.
5. By reversing glycolytic processes, phosphoenolpyruvate is converted into fructose 1,6- bisphosphate.
6. Fructose-1,6-bisphosphate is converted to fructose-6-phosphate in the reaction releasing inorganic phosphate and is catalysed by fructose-1,6-bisphosphatase.
7. The enzyme phosphoglucoisomerase converts fructose-6-phosphate to glucose-6-phosphate.
8. Glucose-6-phosphate generates inorganic phosphate that yields free glucose, which enters the blood. Glucose-6-phosphatase is the enzyme involved.

In the Mitochondria

Pyruvate + ATP ⟶ Oxaloacetate + ADP + Pi

Oxaloacetate + NADH ⟶ Malate + NAD^+

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The conversion to malate enables the molecule to be transferred out of mitochondria. It is converted back to oxaloacetate in the cytoplasm.

In the cytoplasm
Malate + NAD^+ ⟶ Oxaloacetate + NADH
Oxaloacetate + GTP ⟶ PEP + GDP
It then passes through the same intermediates that glycolysis does. The endoplasmic reticulum is the location of the final reaction.

In the Endoplasmic Reticulum
G6P → glucose (catalyst : glucose - 6 - phosphatase)
Glucose is transported out of the cell into the extracellular environment by a glucose transporter.

Importance :-

- During deprivation, the gluconeogenesis cycle is important for blood glucose regulation.
- Many cells and tissues, including RBCs, neurons, skeletal muscle, the medulla of the kidney, testes and embryonic tissue, rely on glucose to meet their energy needs.
- The gluconeogenesis cycle removes metabolites such as lactate (produced by muscles and RBCS) and glycerol from the bloodstream (produced from adipose tissue).