

# Glucose Metabolism : (Glycolysis & Krebs Cycle)

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# Outline



- Introduction Glycolysis
- Characteristics of Glycolysis
- Phases of Glycolysis
- Krebs Cycle
- Energy Yield of Krebs Cycle
- Medical Significance

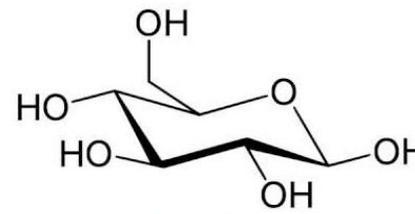
## ❖ Definition of Glycolysis

- Is the metabolic process in which **one molecule of glucose** is broken down into **two molecules of pyruvate**, producing energy in the **form of ATP and NADH**.

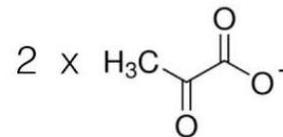
➤ Occurs in the **cytoplasm**.

➤ Does not **require oxygen**.

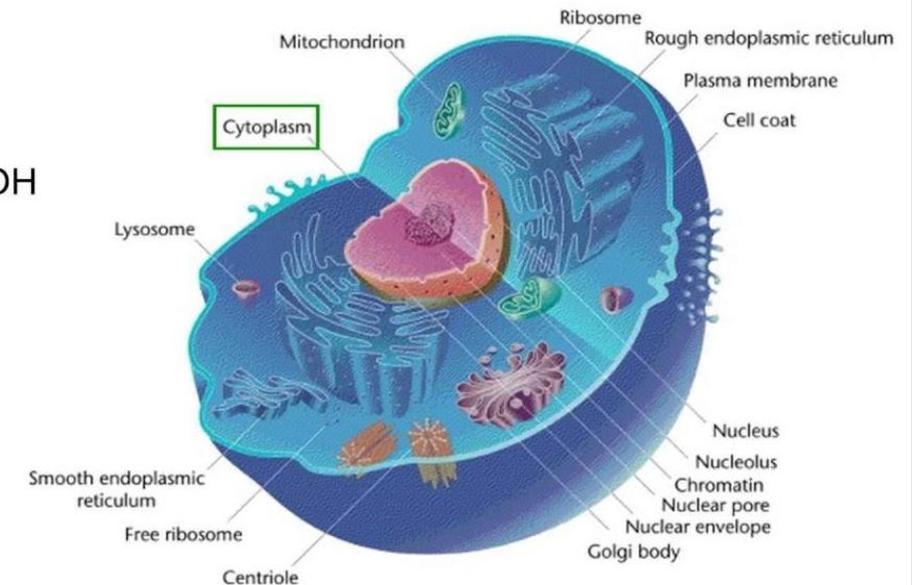
**glycolysis** occurs in the **cytoplasm**



**glucose**



**pyruvate**





## ❑ Characteristics of Glycolysis:

- 1) Universal pathway in living organisms.
- 2) Takes place in the cytoplasm.
- 3) Independent of oxygen.
- 4) Produces ATP quickly.
- 5) First stage of cellular respiration



## ❖ Overall Reaction of Glycolysis:

• **Glucose  $\rightarrow$  2 Pyruvate + 2 ATP (net) + 2 NADH + 2 H<sub>2</sub>O.**

### ➤ Phases of Glycolysis:

• Glycolysis occurs in **two main phases**, each with a specific function in breaking down glucose and producing energy.

✓ Energy Investment Phase (Preparatory Phase).

✓ Energy Payoff Phase.

## ❖ Energy Investment Phase:



- In this phase, the cell uses **2 ATP to activate glucose** and split it into two **3-carbon molecules**.

### ➤ Main features:

- i. The cell uses 2 ATP molecules.
  - ii. Glucose is activated by phosphorylation.
  - iii. A 6-carbon glucose molecule is split into two 3-carbon molecules
- **Enzymes Involved:** Hexokinase, Phosphoglucose isomerase, Phosphofructokinase-1, Aldolase, Triose phosphate isomerase.

## ❖ Energy Payoff Phase:



- In this phase, energy is produced in the form of ATP and NADH.
  1. Produces 4 ATP molecules.
  2. Produces 2 NADH molecules.
  3. Forms 2 pyruvate molecules.
- Enzymes Involved: Glyceraldehyde-3-phosphate dehydrogenase, Phosphoglycerate kinase, Phosphoglycerate mutase, Enolase, Pyruvate kinase.

## ❖ Steps of Glycolysis:



- 1) Glucose  $\rightarrow$  Glucose-6-phosphate.
- 2) Glucose-6-phosphate  $\rightarrow$  Fructose-6-phosphate.
- 3) Fructose-6-phosphate  $\rightarrow$  Fructose-1,6-bisphosphate.
- 4) Fructose-1,6-bisphosphate  $\rightarrow$  DHAP + G3P.
- 5) DHAP  $\rightarrow$  G3P.
- 6) G3P  $\rightarrow$  1,3-bisphosphoglycerate
- 7) 1,3-bisphosphoglycerate  $\rightarrow$  3-phosphoglycerate
- 8) 3-phosphoglycerate  $\rightarrow$  2-phosphoglycerate
- 9) 2-phosphoglycerate  $\rightarrow$  Phosphoenolpyruvate (PEP)
- 10) PEP  $\rightarrow$  Pyruvate

## ❖ Energy Yield from Glycolysis:

- From one glucose molecule:
  - 2 ATP (net gain)
  - 2 NADH
  - 2 Pyruvate
- This energy supports many cellular activities.

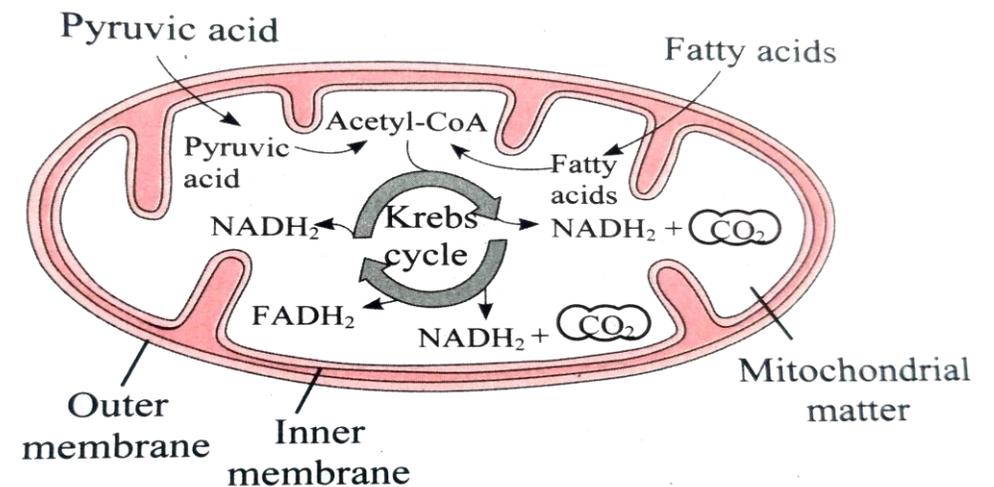
## ❖ **Medical Importance of Glycolysis:**

### ➤ **Glycolysis is medically important because:**

- ✓ Essential energy source in red blood cells.
- ✓ Increased activity in cancer cells.
- ✓ Important in diabetes and metabolic diseases.
- ✓ Enzyme deficiencies may cause disorders

## ❖ Definition of Krebs Cycle

- Is a cyclic series of **enzyme-controlled reactions** that oxidize **acetyl-CoA** to **carbon dioxide** ( $\text{CO}_2$ ) while producing **NADH**, **FADH<sub>2</sub>**, and **ATP**.
- It occurs in the **mitochondrial matrix** of eukaryotic cells.



## ❖ **Link Reaction (Transition Step):**

### ➤ **Before entering the Krebs cycle:**

- Pyruvate from glycolysis enters the mitochondria
  - Converted to acetyl-CoA by pyruvate dehydrogenase
  - Releases CO<sub>2</sub>
  - Produces NADH
- This step connects glycolysis to the Krebs cycle.

# ❖ Steps of the Krebs Cycle with Enzymes



1. Acetyl-CoA + Oxaloacetate  $\rightarrow$  Citrate
2. Citrate  $\rightarrow$  Isocitrate
3. Isocitrate  $\rightarrow$   $\alpha$ -Ketoglutarate + CO<sub>2</sub>
4.  $\alpha$ -Ketoglutarate  $\rightarrow$  Succinyl-CoA + CO<sub>2</sub>
5. Succinyl-CoA  $\rightarrow$  Succinate
6. Succinate  $\rightarrow$  Fumarate
7. Fumarate  $\rightarrow$  Malate
8. Malate  $\rightarrow$  Oxaloacetate

## ❖ Main regulatory enzymes:

1. Citrate synthase
2. Aconitase
3. Isocitrate dehydrogenase
4.  $\alpha$ -Ketoglutarate dehydrogenase
5. Succinyl-CoA synthetase
6. Succinate dehydrogenase
7. Fumarase
8. Malate dehydrogenase



## ❖ Energy Yield of Krebs Cycle



- The Krebs cycle generates high-energy molecules that are later used to produce ATP in the electron transport chain.
- Energy Yield per One Turn of the Krebs Cycle (From one acetyl-CoA)
  - I. 3 NADH
  - II. 1 FADH<sub>2</sub>
  - III. 1 ATP
  - IV. 2 CO<sub>2</sub>

# ❖ Energy Yield per One Glucose Molecule



- Since one glucose produces two acetyl-CoA, the Krebs cycle runs twice.

- Total energy yield per glucose:

- I. 6 NADH

- II. 2 FADH<sub>2</sub>

- III. 2 ATP (or GTP)

- IV. 4 CO<sub>2</sub>

## ❖ Medical Significance



- Essential for aerobic energy production
- Mitochondrial disorders affect the cycle (Muscle weakness)
- Important in metabolic diseases (Obesity, cancer, diabetes)
- Disruption reduces ATP supply (Exercise intolerance)



# References

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**Thanks**