

Carbohydrate Metabolism

Carbohydrate Metabolism

Carbohydrate metabolism includes the breakdown, synthesis, and transformation of carbohydrates to produce energy and maintain glucose levels.

Key Stages:

1. Glycolysis

- **Location:** Cytoplasm
- **Process:** Glucose → 2 Pyruvate
- **Energy:** 2 ATP (net), 2 NADH
- **Note:** Anaerobic; first step in glucose utilization

2. Pyruvate Decarboxylation

- **Location:** Mitochondria
- **Process:** Pyruvate → Acetyl CoA
- **Link:** Connects glycolysis to TCA cycle

3. Citric Acid Cycle (TCA/Krebs)

- **Location:** Mitochondrial matrix
- **Process:** Acetyl CoA oxidation
- **Energy:** 3 NADH, 1 FADH₂, 1 GTP per cycle
- **Function:** Supplies electrons for ETC

4. Electron Transport Chain (ETC) & Oxidative Phosphorylation

- **Location:** Inner mitochondrial membrane
- **Process:** NADH/FADH₂ → ATP via proton gradient
- **Energy:** ~34 ATP per glucose
- **Final Product:** Water (O₂ reduced)

5. Gluconeogenesis

- **Location:** Liver & kidney
- **Process:** Non-carb precursors → Glucose
- **Role:** Maintains glucose during fasting

6. Glycogenesis & Glycogenolysis

- **Glycogenesis:** Glucose → Glycogen (storage)
- **Glycogenolysis:** Glycogen → Glucose (release)
- **Regulation:** Insulin (storage), Glucagon (release)

7. Pentose Phosphate Pathway (PPP)

- **Location:** Cytoplasm
- **Purpose:** Produces NADPH & Ribose-5-phosphate
- **Uses:** Fatty acid & nucleotide synthesis, antioxidant defense

Hormonal Control

- **Insulin:** Enhances glucose uptake, storage
- **Glucagon:** Increases glucose production

Glycolysis

Definition:

- Glycolysis is a fundamental metabolic pathway that converts one molecule of glucose into two molecules of pyruvate, generating energy in the form of **ATP** and **NADH**.
- It takes place in the **cytoplasm** of all cells and can proceed **anaerobically** (without oxygen).

Phases of Glycolysis

- Glycolysis consists of **two distinct phases**:
 1. **Energy Investment Phase (Preparatory Phase)**
 2. **Energy Generation Phase (Payoff Phase)**

Energy Investment Phase (Preparatory Phase)

- The energy investment phase of glycolysis involves the initial consumption of ATP to prepare glucose for further breakdown.

The steps are as follows:

1. Phosphorylation of Glucose

- Glucose is phosphorylated to glucose-6-phosphate (G6P).
- **Enzyme:** Hexokinase
- **ATP used:** 1

2. Isomerization

- G6P is isomerized to fructose-6-phosphate (F6P).
- **Enzyme:** Phosphoglucose isomerase

3. Second Phosphorylation

- F6P is phosphorylated to fructose-1,6-bisphosphate (F1,6BP).
- **Enzyme:** Phosphofructokinase-1 (PFK-1)
- **ATP used:** 1

4. Cleavage

- F1,6BP is cleaved into two 3-carbon molecules: glyceraldehyde-3-phosphate (G3P) and dihydroxyacetone phosphate (DHAP).
- **Enzyme:** Aldolase

5. Isomerization of DHAP

- DHAP is converted into another G3P.
- **Enzyme:** Triose phosphate isomerase

Energy Generation Phase (Payoff Phase)

- This phase produces ATP and NADH by processing the two glyceraldehyde-3-phosphate molecules formed in the investment phase.

The steps are as follows:

1. Oxidation and Phosphorylation

- Each G3P is oxidized to 1,3-bisphosphoglycerate (1,3BPG).
- **Enzyme:** Glyceraldehyde-3-phosphate dehydrogenase (GAPDH)
- **NADH produced:** 1 per G3P (total 2 NADH)

2. ATP Formation

- 1,3BPG donates phosphate to ADP, forming ATP and 3-phosphoglycerate (3PG).
- **Enzyme:** Phosphoglycerate kinase
- **ATP produced:** 1 per G3P (total 2 ATP)

3. Conversion

- 3PG is converted to 2-phosphoglycerate (2PG).
- **Enzyme:** Phosphoglycerate mutase

4. Dehydration

- 2PG is dehydrated to form phosphoenolpyruvate (PEP).
- **Enzyme:** Enolase

5. Final ATP Formation

- PEP donates phosphate to ADP, forming ATP and pyruvate.
- **Enzyme:** Pyruvate kinase
- **ATP produced:** 1 per G3P (total 2 ATP)

Energetics

- ATP used: 2
- ATP produced: 4
- Net ATP gain: 2
- NADH produced: 2

Tricarboxylic Acid (TCA) cycle or Citric acid cycle (TCA)

- The Citric Acid Cycle, also known as the Krebs cycle or the Tricarboxylic Acid (TCA) cycle, is a cornerstone of cellular metabolism, pivotal in the breakdown and conversion of carbohydrates, fats, and proteins into usable energy.
- This cycle takes place in the mitochondrial matrix of eukaryotic cells, where it serves the dual purpose of generating high-energy molecules (ATP, NADH, and FADH₂) and facilitating carbon dioxide excretion as a byproduct.

Citric Acid Cycle or Krebs cycle Pathway

1. Formation of Citrate:

- **Enzyme:** Citrate synthase
- **Process:** Acetyl CoA (2 carbons) combines with oxaloacetate (4 carbons) to form citrate (6 carbons), releasing CoA.

2. Isomerization to Isocitrate:

- **Enzyme:** Aconitase
- **Process:** Citrate is rearranged into isocitrate via cis-aconitate as an intermediate.

3. Oxidation and Decarboxylation to α -Ketoglutarate:

- **Enzyme:** Isocitrate dehydrogenase
- **Process:** Isocitrate is oxidized to oxalosuccinate (6 carbons), then decarboxylated to α -ketoglutarate (5 carbons), producing NADH and releasing CO₂.

4. Further Oxidation and Decarboxylation:

- **Enzyme:** α -Ketoglutarate dehydrogenase complex
- **Process:** α -Ketoglutarate is further oxidized and decarboxylated to form succinyl CoA (4 carbons), generating another NADH and releasing a second CO₂ molecule.

5. Conversion to Succinate:

- **Enzyme:** Succinyl-CoA synthetase
- **Process:** Succinyl CoA is converted into succinate, producing one molecule of GTP (or ATP).

6. Oxidation of Succinate:

- **Enzyme:** Succinate dehydrogenase
- **Process:** Succinate is oxidized to fumarate, reducing FAD to FADH₂.

7. Hydration to Malate:

- **Enzyme:** Fumarase
- **Process:** Fumarate is hydrated to form malate.

8. Oxidation to Oxaloacetate:

- **Enzyme:** Malate dehydrogenase
- **Process:** Malate is oxidized back to oxaloacetate, reducing NAD⁺ to NADH and preparing the cycle to begin anew.

Products of the Krebs Cycle per Acetyl CoA

1. **3 NADH molecules:** For use in the electron transport chain.
2. **1 FADH₂ molecule:** Also, for use in the electron transport chain.
3. **1 ATP (or GTP) molecule:** Directly usable energy.
4. **2 CO₂ molecules:** Waste products released.

Energetics of the Citric Acid Cycle

- **3 NADH → ~7.5 ATP** (via oxidative phosphorylation)
- **1 FADH₂ → ~1.5 ATP**
- **1 GTP (or ATP) directly produced** Each cycle generates around **10 ATP equivalents**.

Glycogen metabolism Pathways



FREE PREVIEW

[Click here to visit our website](#)

PHARMACY PREMIUM NOTES

Complete subject
and semesters are
available on
FirstHope app only.



[Scan or click here](#)

Click here to get the app



Available on Google Play

JOIN THE FIRSTHOPE COMMUNITY

Join our Telegram channel

Click here to join Telegram



[Scan or click here](#)

@FirstHopeNotes

Instagram

@firsthope.official

[Click here to follow >](#)

YouTube channel

FirstHope-Pharmacy / Live streams

[Click here to watch >](#)

WhatsApp channel

Follow FirstHope on WhatsApp

[Click here to join >](#)

FirstHope website

firsthopenotes.com

[Click here to visit >](#)

B.Pharm / D.Pharm / M.Pharm / Pharm.D

Preview notes. Complete subjects and semesters in the FirstHope app.