GLYCOLYSIS

Definition:

Glycolysis is defined as the sequence of reactions for the breakdown of Glucose (6-carbon molecule) to two molecules of pyruvic acid (3-carbon molecule) under aerobic conditions; or lactate under anaerobic conditions along with the production energy in the form of ATP (Adenosine Triphosphate).

This pathway was described by Embden, Meyerhof and Parnas. Hence, it is also called as **Embden-Meyerhof pathway** (EM pathway). In The Glycolytic pathway oxidation of glucose to pyruvate takes place with the generation of ATP and NADH.

Net Reaction: **Glucose + 2NAD+ + 2Pi + 2ADP = 2Pyruvate + 2ATP + 2NADH + $2H_2O$**

Site of Glycolysis

Glycolysis occurs in the **Cytosol or Cytoplasm** of all the cells of the body.

Two types of Glycolysis

Aerobic Glycolysis:	**Anaerobic Glycolysis**:
It occurs when oxygen is plentiful	It occurs when oxygen is scarce
Final product is **pyruvate** along with the production of eight ATP molecules	Final product is **lactate** along with the production of two ATP molecules
Under aerobic conditions, pyruvate converted by pyruvate dehydrogenase to acetyl coenzyme A (CoA) which can then enter the citric acid cycle.	Under anaerobic conditions, pyruvate is converted to lactate by lactate dehydrogenase (LDH). When oxygen becomes available, the lactate is converted back to Pyruvate.

Phases of Glycolysis:

Glucose is converted to Pyruvate in 10 steps by glycolysis. The glycolytic patway can be divided into two phases:

1. Preparatory Phase

This phase is also called **glucose activation phase.** In this phase two molecules of ATP are consumed and the hexose chain is cleaved into two triose phosphates. During this, phosphorylation of glucose and it's conversion to glyceraldehyde-3-phosphate take place. The steps 1, 2, 3, 4 and 5 together are called as the preparatory phase.

2. Payoff Phase

This phase is also called **energy extraction phase**. During this phase, conversion of glyceraldehyde-3-phophate to pyruvate and the coupled formation of ATP take place. The steps after 5 constitute payoff phase.

Reactions of Glycolysis (Trick **PIPLIOSIDS**)

1. Phosphorylation: Uptake and phosphorylation of Glucose to Glucose-6-Phosphate with the consumption one **ATP**.
2. Isomerization: Isomerization of Glucose-6-Phosphateto to Fructose-6-Phosphate.
3. Phosphorylation: Phosphorylation of Fructose-6-Phosphate to Fructose-1,6-Biphosphate with the consumption one **ATP.**
4. Lysis: Cleavage of Fructose-1, 6-Biphosphate to two molecule Glyceraldehyde 3 phosphate.
5. Isomerization: Isomerization of Glyceraldehyde 3 phosphate (GAP) to DHAP (Dihydroxyacetone Phophate).
6. Oxidation by dehydrogenation: Oxidative phosphorylation of GAP to 1,3-Bisphosphoglycerate with the formation of two molecule **NADH** (Necotinamide adenine dinucleotide)
7. Substrate level phosphorylation: Conversion of 1, 3-Bisphosphoglycerate to 3-Phosphoglycerate with the formation of **ATP.**
8. Isomerization: Conversion of 3-Phosphoglycerate to 2-Phosphoglycerate
9. Dehydration: Conversion of 2-Phosphoglycerate to Phosphoenolpyruvate with the release of water molecule.
10. Substrate level phosphorylation: Conversion of Phosphoenol Pyruvate to Pyruvate with the formation of **ATP.**

Energetics of Glycolysis

A. Aerobic Glycolysis

Step	Enzyme	Source	No. of ATP
1	Hexokinase	–	-1
3	Phosphofructokinase	–	-1
6	Glyceraldehyde-3- phosphate dehydrogenase	NADH	(3) x 2 = 6
7	Phosphoglycerate kinase	ATP	(1) x 2 = 2
10	Pyruvate kinase	ATP	(1) x 2 = 2
Net Yield			**8 ATPs**

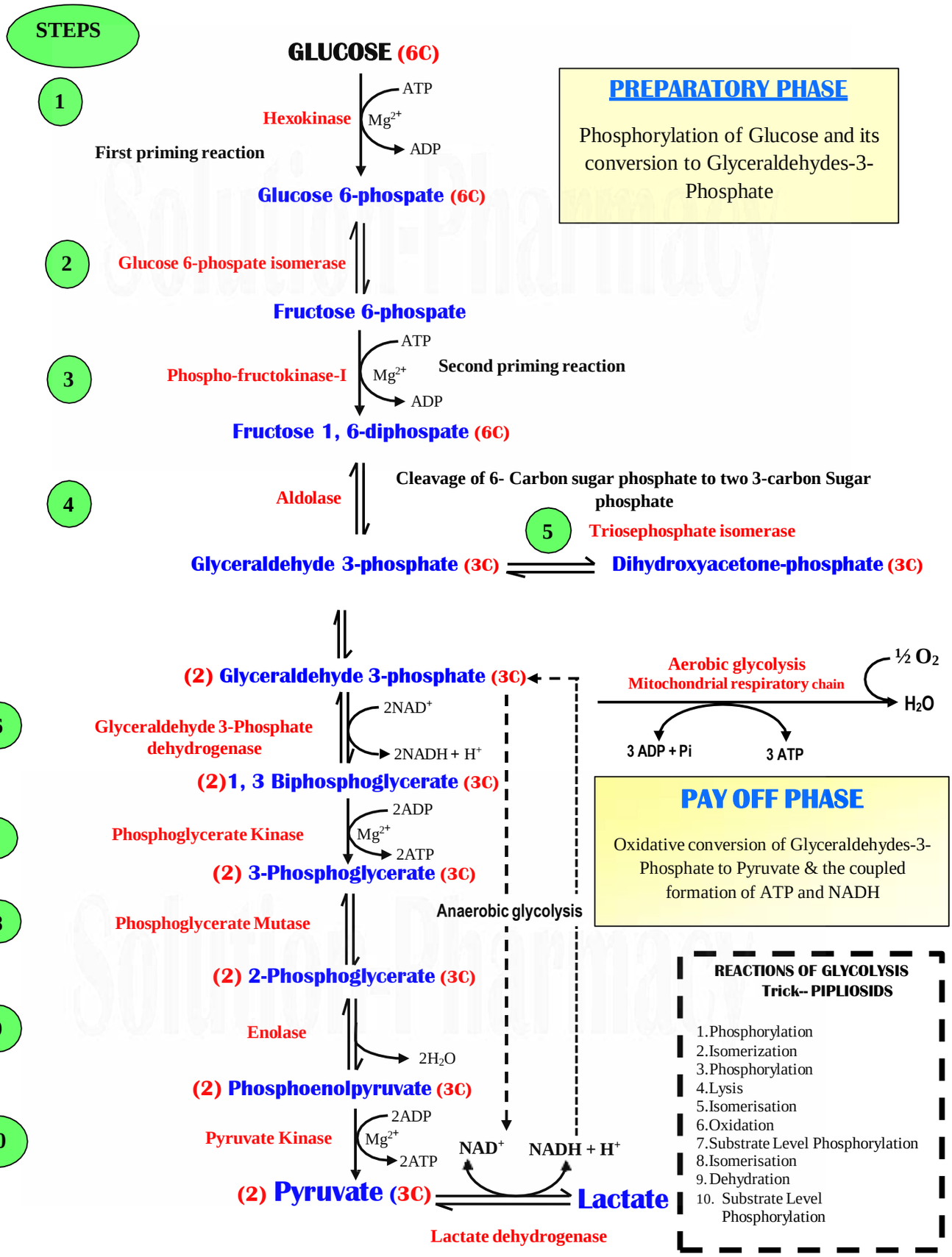
B. Anaerobic Glycolysis

Step	Enzyme	Source	No. of ATP Formed/consumed
1	Hexokinase	–	-1
3	Phosphofructokinase	–	-1
7	Phosphoglycerate kinase	ATP	(1) x 2 = 2
10	Pyruvate kinase	ATP	(1) x 2 = 2
Net Yield			**2 ATPs**

Significance of the Glycolytic Pathway

1. Glycolysis is a universal pathway, **taking place in all organisms**, from yeast to mammals.
2. Glycolysis can be function either **aerobically or anaerobically**. In the presence of O_2, pyruvate is further oxidized to CO_2. In the absence of O_2, pyruvate can be fermented to lactate or Ethanol.
3. Glycolysis is the only **source of energy** in erythrocytes due to lack of mitochondria.
4. Main way to produce ATP in some tissue (RBC, retina, testis, skin, medulla of kidney)
5. During strenuous exercise, when muscle tissue lacks enough oxygen, **anaerobic glycolysis** forms the major **source of energy for muscles**.
6. The glycolytic pathway may be considered as the preliminary step before complete oxidation.
7. The glycolytic pathway provides **carbon skeletons for synthesis** of **non-essential amino acids.**
8. DHAP and Glyceraldehyde 3 phosphate, important for Lipogenesis **(glycerol part of fat.)**
9. Most of the reactions of the glycolytic pathway are reversible, which are also used for **gluconeogenesis.**

GLYCOLYSIS



PREPARATORY PHASE

Phosphorylation of Glucose and its conversion to Glyceraldehydes-3-Phosphate

PAY OFF PHASE

Oxidative conversion of Glyceraldehydes-3-Phosphate to Pyruvate & the coupled formation of ATP and NADH

REACTIONS OF GLYCOLYSIS
Trick-- PIPLIOSIDS

1. Phosphorylation
2. Isomerization
3. Phosphorylation
4. Lysis
5. Isomerisation
6. Oxidation
7. Substrate Level Phosphorylation
8. Isomerisation
9. Dehydration
10. Substrate Level Phosphorylation