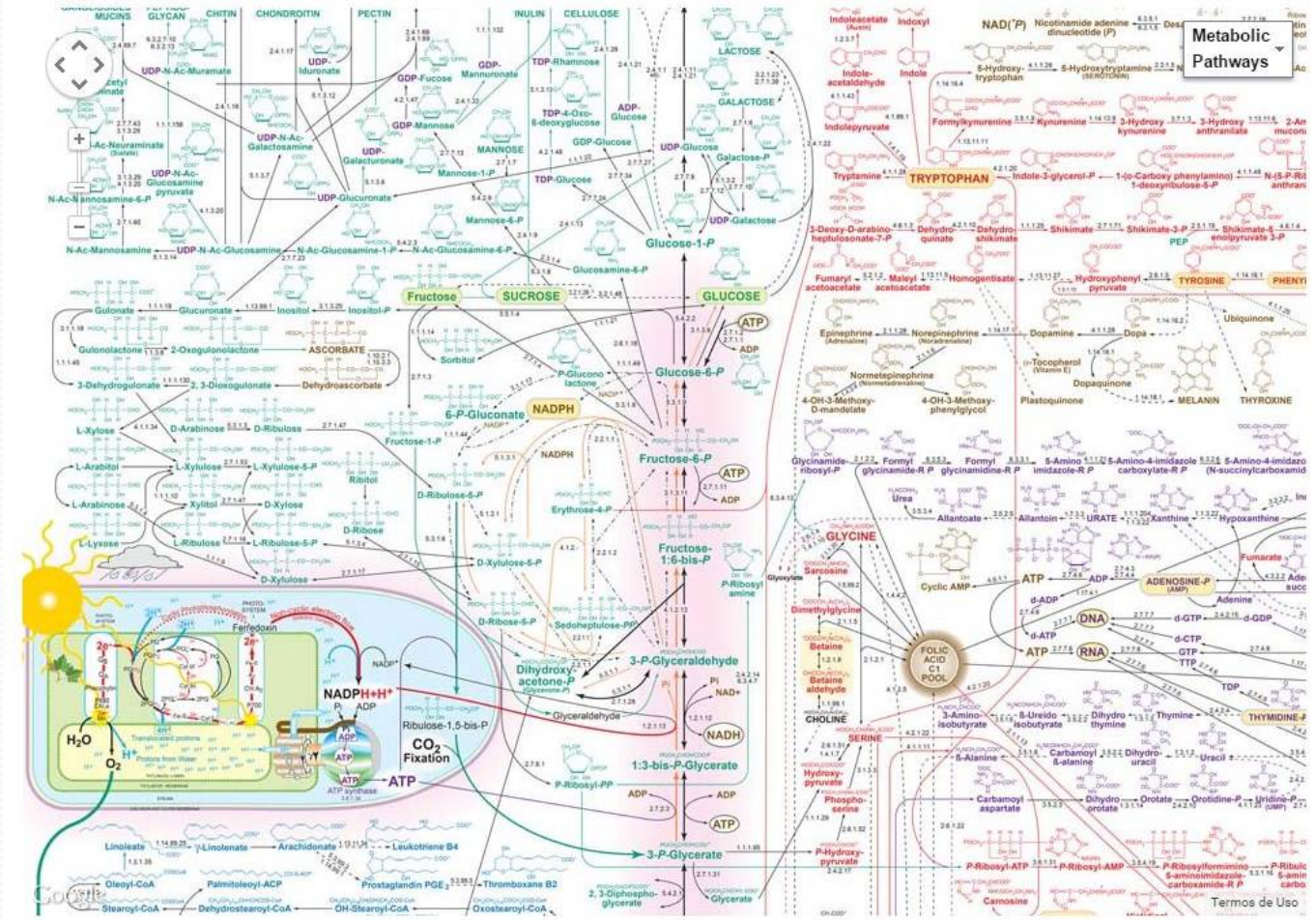
Introduction to Carbohydrate metabolism



Some metabolic pathways of carbohydrates

- 1- Glycolysis
- 2- Krebs cycle
- 3- Glycogenesis
- 4- Glycogenolysis
- 5- Glyconeogenesis

- - Pentose Phosphate Pathway (PPP)
- - Curi cycle
- - Biological oxidation

Metabolism

Metabolism involves :

- *Catabolic reactions* that break down large, complex molecules to provide energy and smaller molecules.
- *Anabolic reactions* that use ATP energy to build larger molecules.

Stages of Carbohydrate Metabolism

Stage 1: Digestion and hydrolysis - break down large molecules to smaller ones that enter the bloodstream.

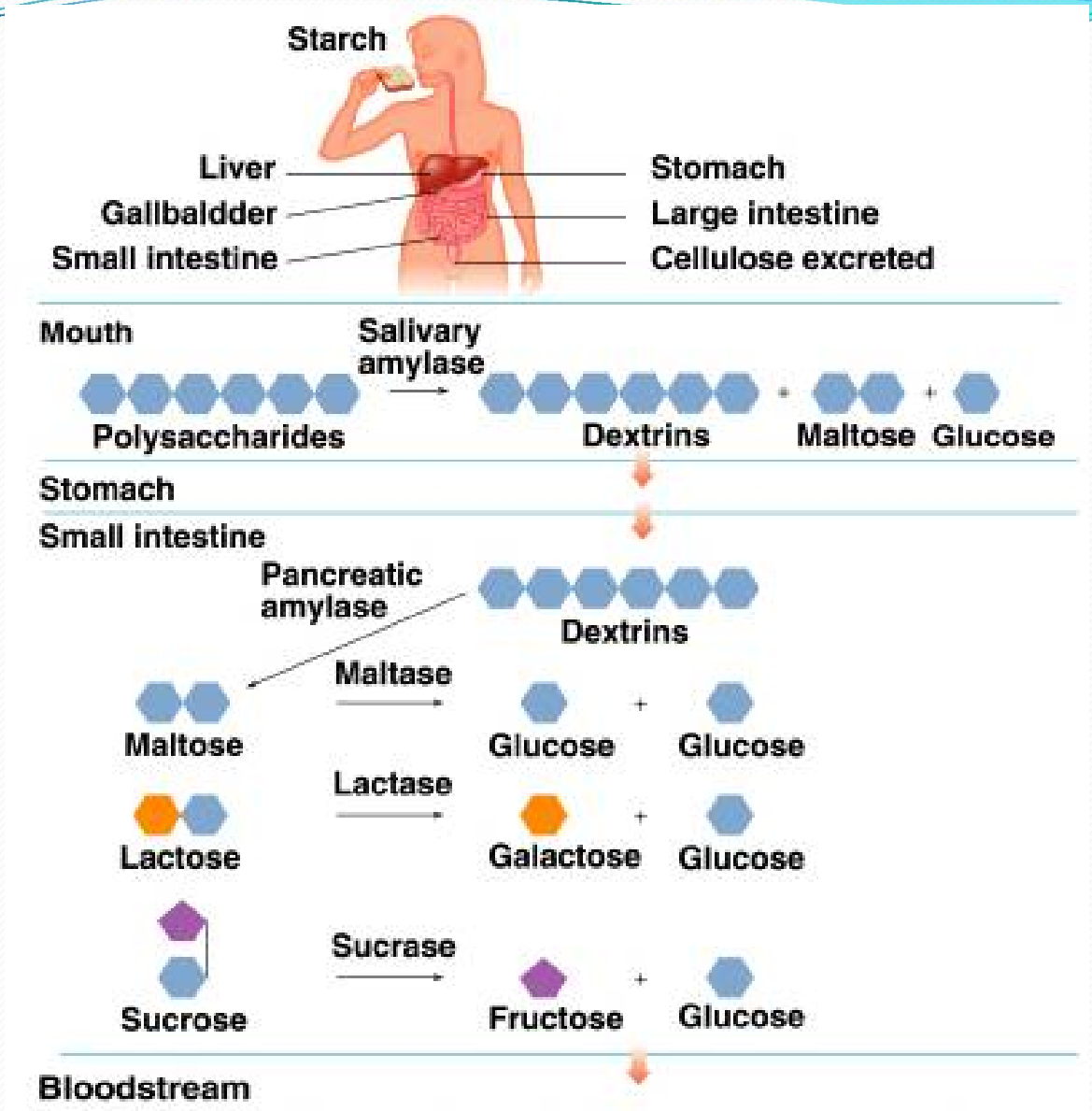
Stage 2: Degradation - breaks down molecules to two- and three-carbon compounds.

Stage 3: Oxidation of small molecules in the citric acid cycle and electron transport provide ATP energy.

Stage 1: Digestion of Carbohydrates

The digestion of carbohydrates:

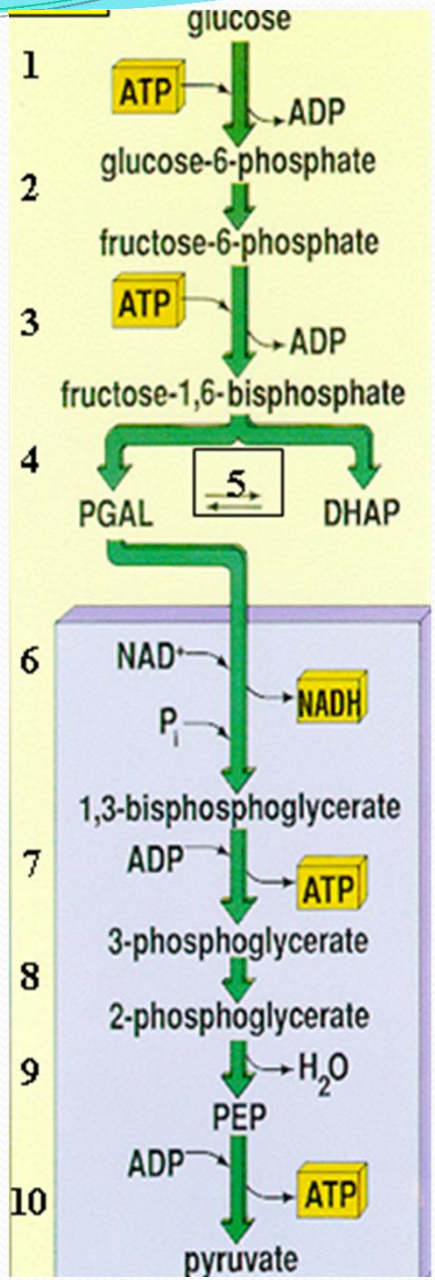
- Begins in the mouth where salivary amylase breaks down polysaccharides to smaller polysaccharides (dextrins), disaccharide (maltose), and some glucose.
- Continues in the small intestine where pancreatic amylase hydrolyzes dextrins to maltose and glucose.
- Hydrolyzes of disaccharides; maltose, lactose, and sucrose to monosaccharides, mostly glucose, which enter the bloodstream for transport to the cells.



Stage 2: Glycolysis

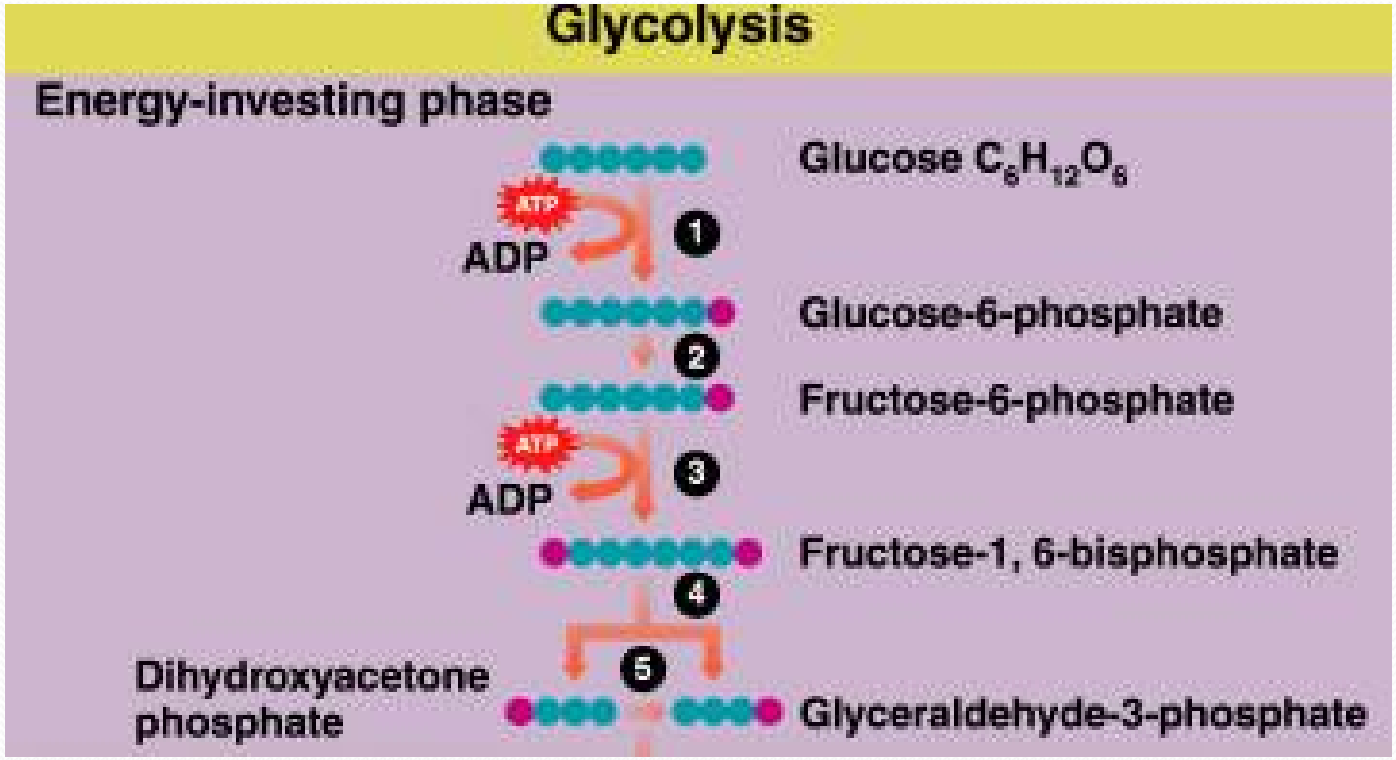
- Glycolysis is a metabolic pathway that degrades glucose (a six-carbon) to pyruvate (a three-carbon molecules).
- It is an anaerobic process (no oxygen) and occur in the cytoplasm.

- It is divided into two stages:
  - A- five reactions and consume energy
  - B- five reactions that produce energy



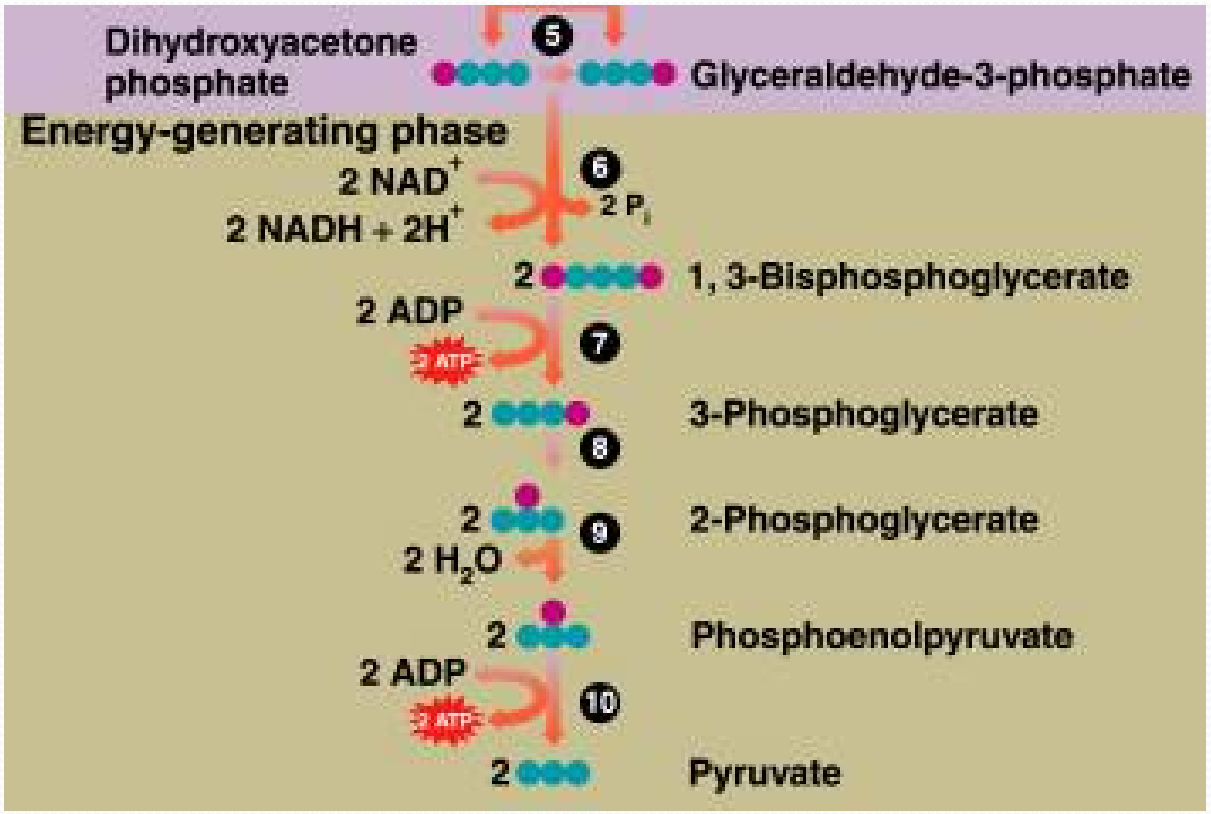
In reactions 1-5 of glycolysis,

- Energy is required to add phosphate groups to glucose.
- Glucose is converted through five enzymatically catalyzed reactions to two three-carbon molecules.



In reactions 6-10 of glycolysis, energy is generated as:

- Sugar phosphates are cleaved to triose phosphates.
- Four ATP molecules are produced.



Glycolysis: Overall Reaction

In glycolysis,

- Two ATP add phosphate to glucose and fructose-6-phosphate.
- Four ATP are formed in energy-generation by direct transfers of phosphate groups to four ADP**.**
- There is a net gain of 2 ATP and 2 NADH.

In other pathway

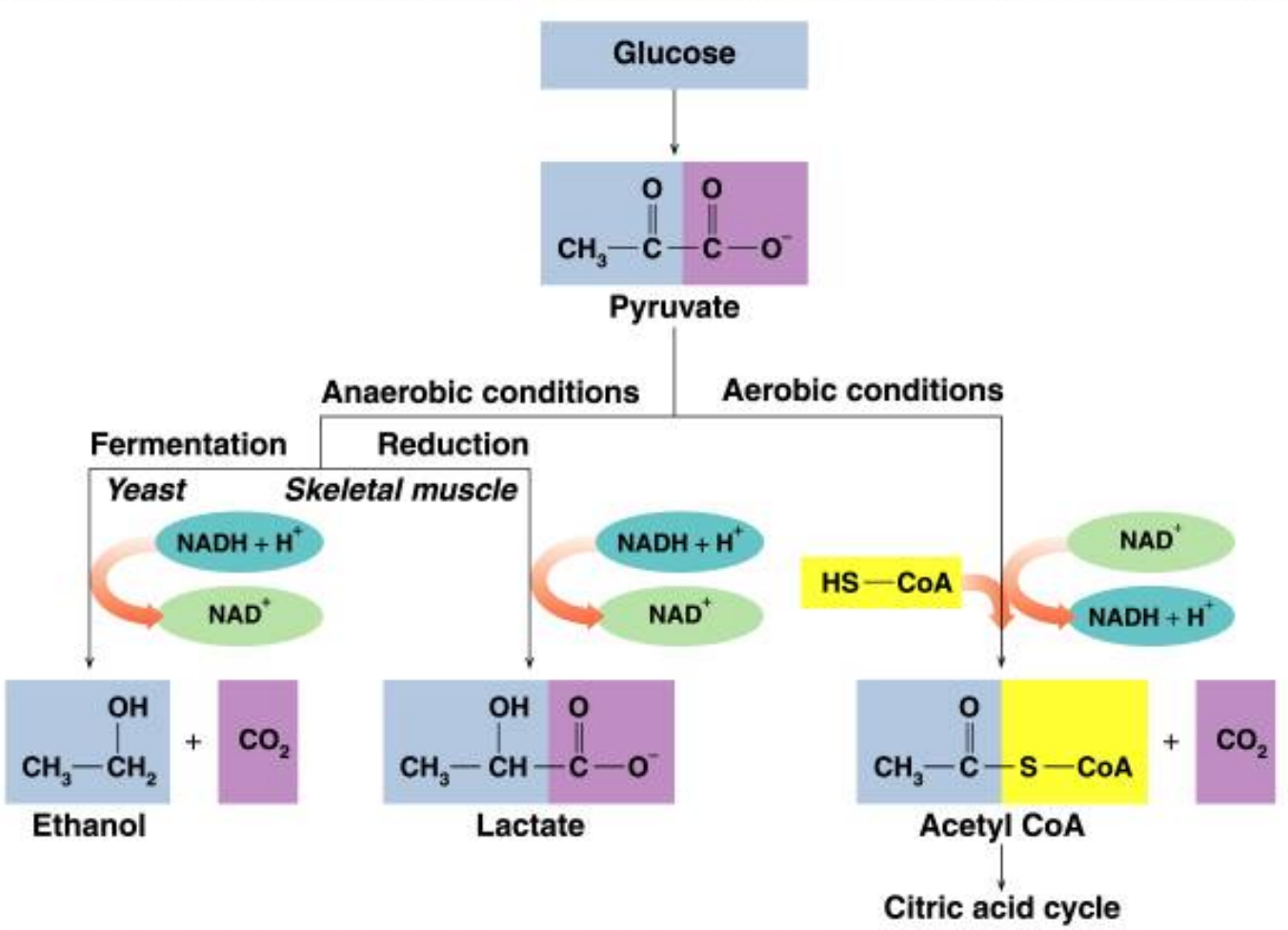
- In mitochondria, each of the 2NADH is converted to NAD^+ and 3ATP are produced (2x 3 = 6ATP)

$$C_6H_{12}O_6 + 2ADP + 2Pi + 2NAD^+ \longrightarrow 2C_3H_3O_3^- + 2ATP + 2NADH + 4H^+$$

Glucose

Pyruvate

The Fate of pyruvate produced from glycolysis



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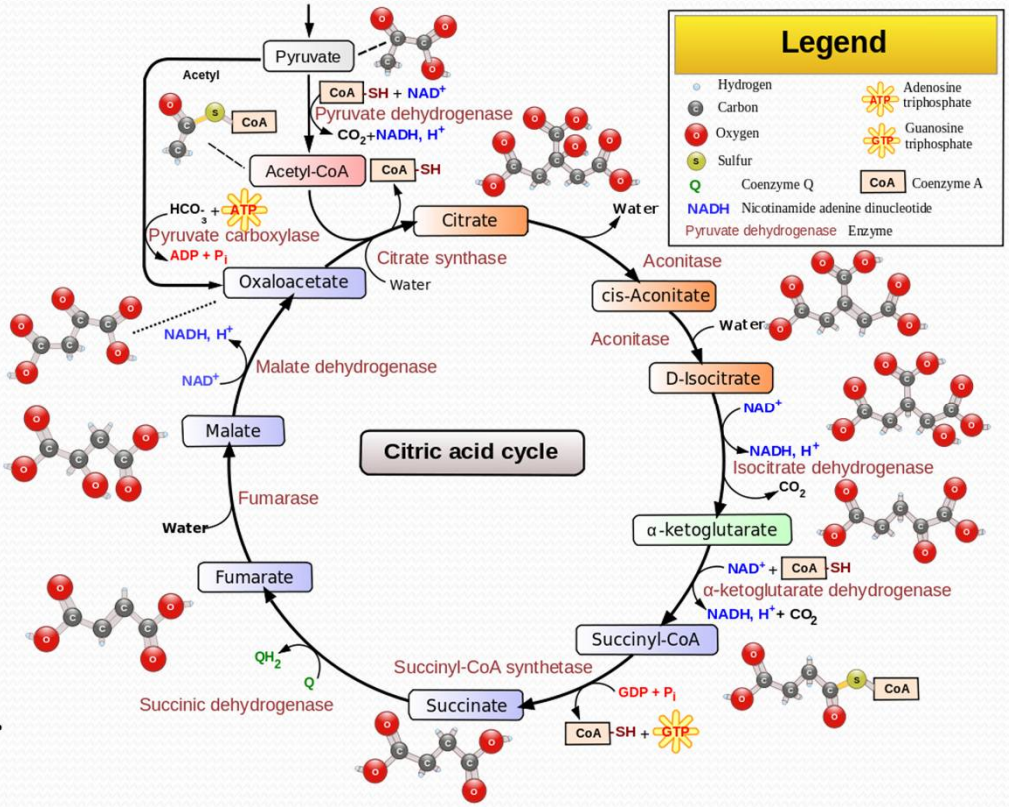
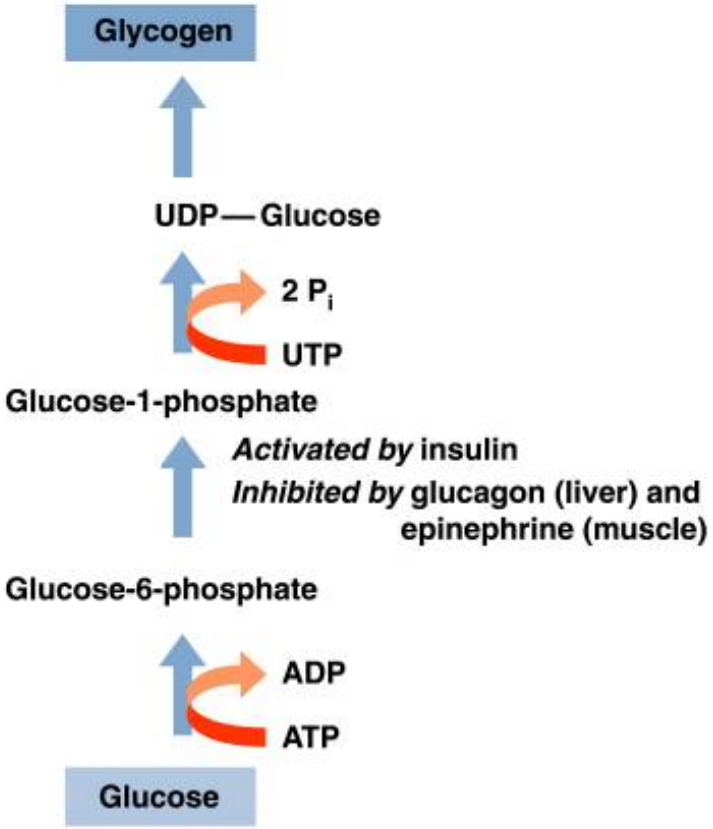
Krebs cycle

- It needs oxygen, so it occurs in all aerobic organisms.
- It is called **citric acid cycle**, **tricarboxylic acid** (**TCA**) **cycle** or the **Krebs cycle.**
- It generates energy through the oxidation of acetyl-CoA derived from carbohydrates, fats and proteins into CO_2 and chemical energy in the form of adenosine triphosphate (ATP).
- It occurs only in mitochondria which is called the “Power House”



Glycogenesis

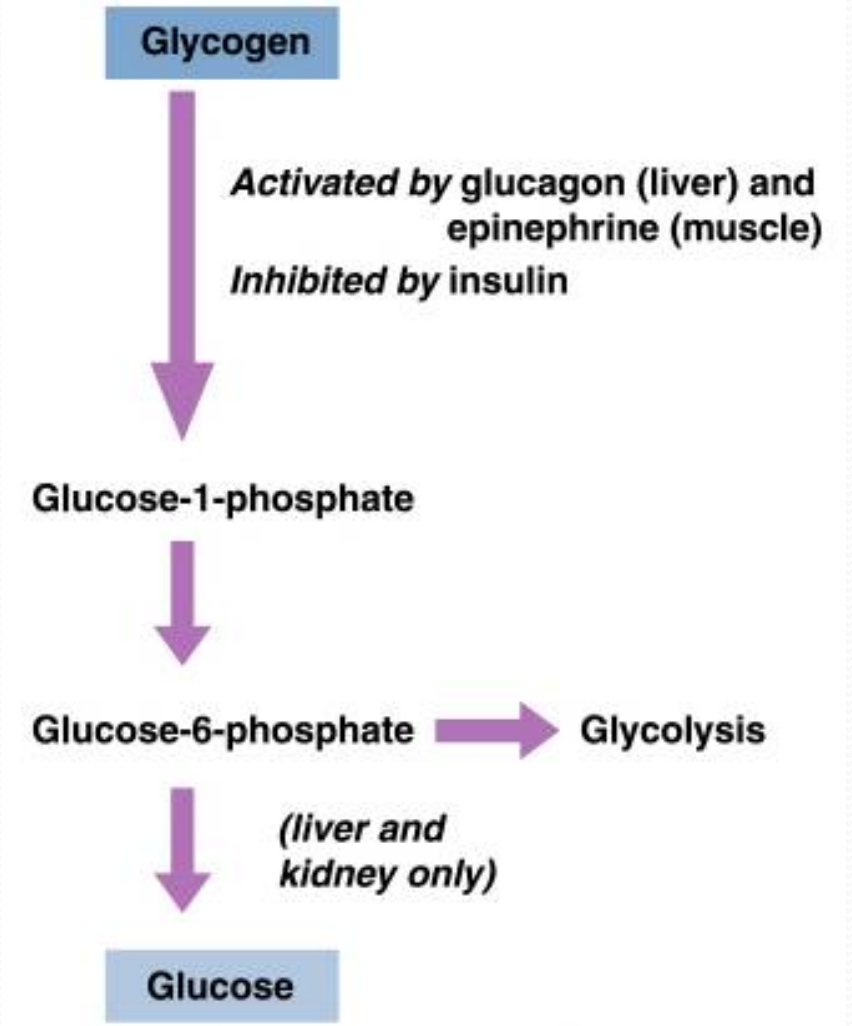
- It is the storing of glucose (monosaccharide) by converting to glycogen (polysaccharide) in liver and muscles.
- It operates when high levels of glucose-6-phosphate are formed in the first reaction of glycolysis.
- It does not operate when energy stores (glycogen) are full, which means that additional glucose is converted to body fat.



Glycogenolysis

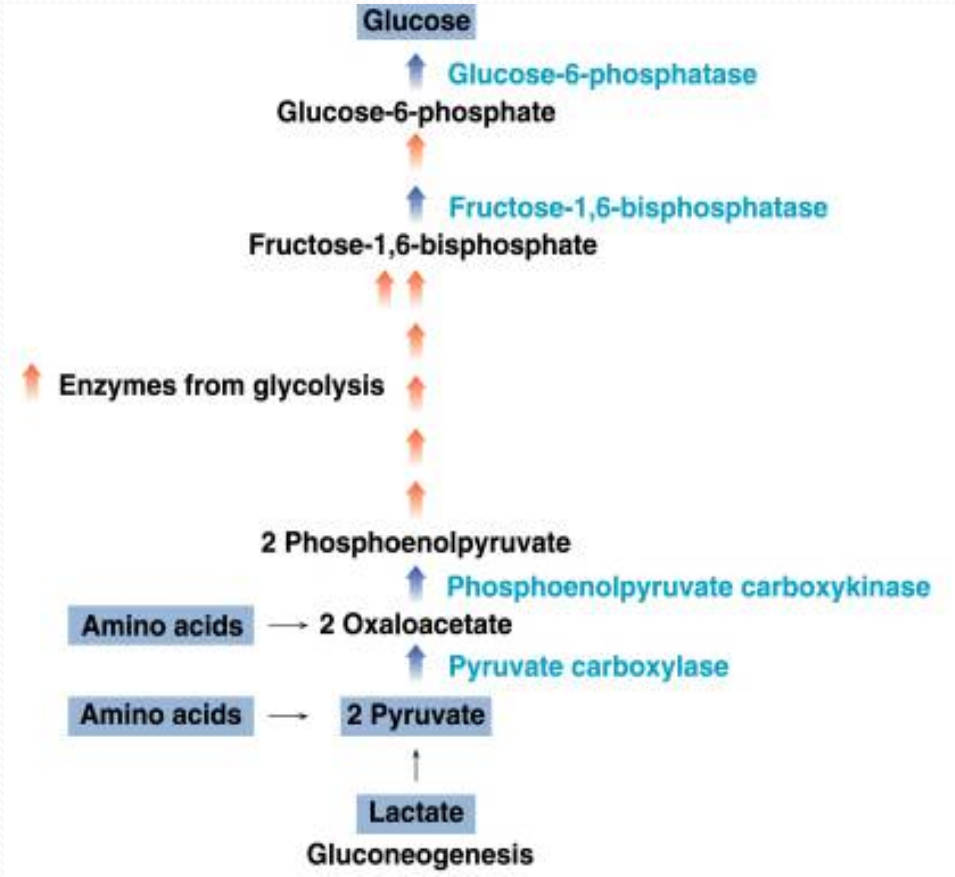
In glycogenolysis

- Glycogen stores in liver and muscles is broken down to glucose.
- Glucose molecules are removed one by one from the end of the glycogen chain to yield glucose-1-phosphate.
- It occurs when the blood glucose level is decreasing to less than the lower limit (70 mg%) to compensate this decrease.



Gluconeogenesis

- It is the generation of glucose from certain non-carbohydrate carbon substrates like the metabolic products of carbohydrates, amino acids and lipid.
- It occurs when glycogen stores are depleted as a result of starvation or if the body can not utilize glucose as in the case of diabetes.



Pentose Phosphate Pathway (PPP)

- The **pentose phosphate pathway** is a metabolic pathway parallel to glycolysis.
- It generates NADPH and pentoses as well as Ribose 5-phosphate, the last one a precursor for the synthesis of nucleotides.

6 Glucose 6-phosphate + 12 $NADP^+$ ⟶
6 Ribulose 5-phosphate + 6 CO_2 + 12 NADPH + 12 H^+ + pi

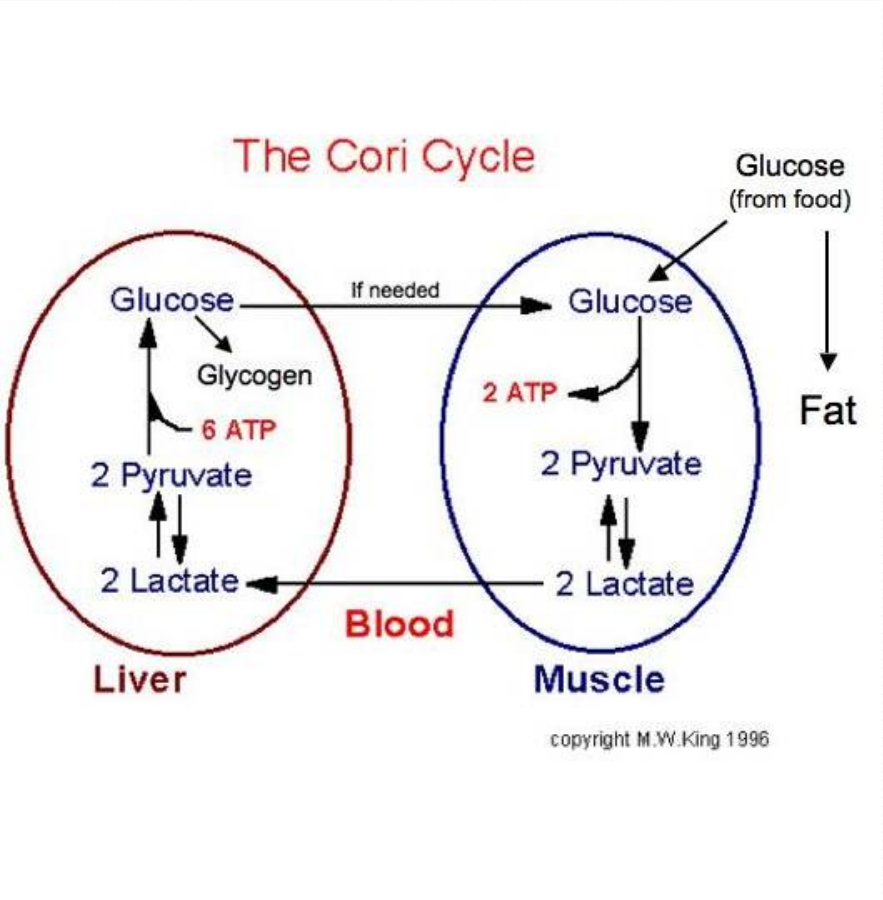
↳ **5 glucose 6-phosphate**

Cori Cycle

The Cori cycle

- It is the flow of lactate and glucose between the muscles and the liver.
- It occurs when anaerobic conditions occur in active muscle and glycolysis produces lactate.
- It operates when lactate moves through the blood stream to the liver, where it is oxidized back to pyruvate.
- It converts pyruvate to glucose, which is carried back to the muscles.

- **Notice:** the formation of glucose from lactate consumes 6 ATP molecules.



Pathways for Glucose