**CONCEPT:** GLYCOLYSIS

Glycolysis overview

● **Glycolysis** is the metabolic pathway responsible for extracting energy from breakdown of sugar

□ Occurs in the _____ and does not require oxygen

□ Glucose + 2 $NAD^+$ + 2 ADP + 2 $P_i$ → 2 pyruvate + 2 NADH + 2 ATP

- Net result from one glucose is: 2 ATP, 2 NADH, and 2 pyruvates

□ Four types of _____ run glycolysis

- **Dehydrogenase:** Oxidizes a molecule by removing $H^+$ and an electron

- **Kinase:** Adds a phosphate group onto a molecule

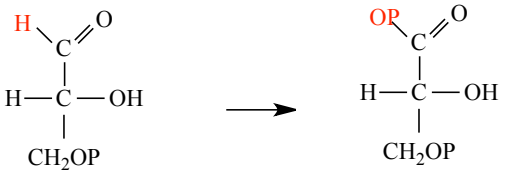
- **Isomerase**: Rearranges bonds within a molecule

- **Mutase:** Shifts a chemical group from one position to another

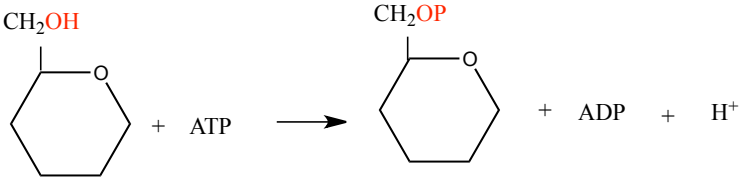
□ Enzymes are regulated by levels of ATP, which means the rate of glycolysis decreases with abundance of ATP

**EXAMPLE:** Four types of enzymes in glycolysis

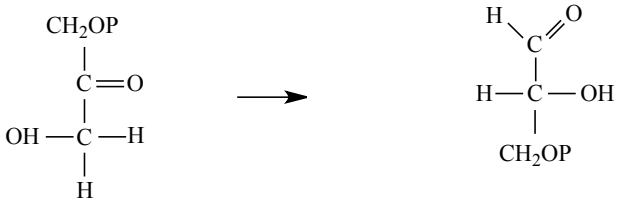
**Dehydrogenase**



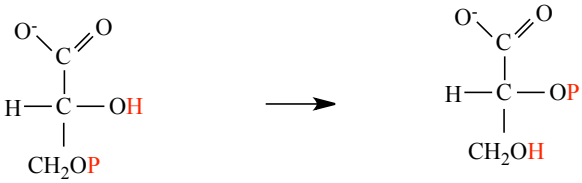
**Kinase**



**Isomerase**

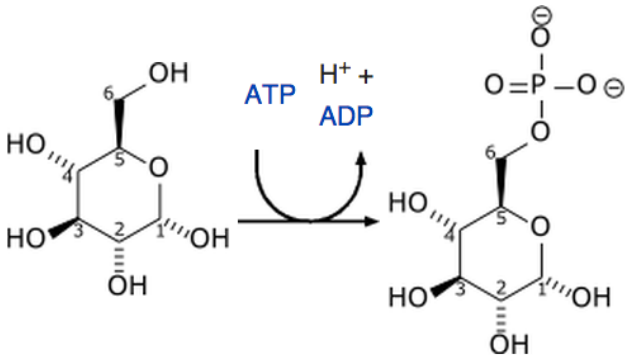


**Mutase**



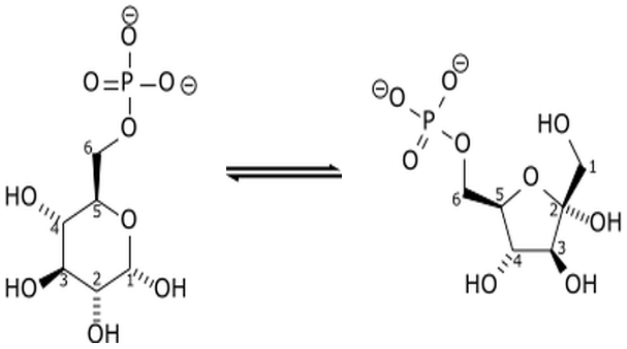
Steps of Glycolysis

1. **Phosphorylation**
    - Glucose is phosphorylated by ATP (this traps glucose inside the cell)



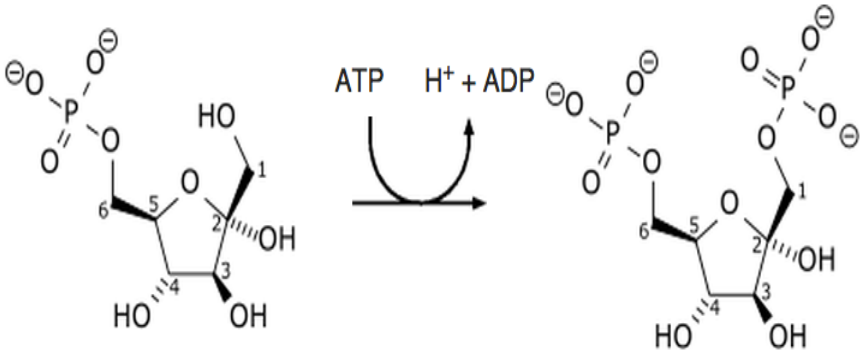

Glucose Glucose 6-phosphate

2. **Oxygen movement**
    - The carbonyl oxygen moves from carbon 1 to carbon 2 (changes from aldose to ketose sugar)



Glucose 6-phosphate Fructose 6-phosphate

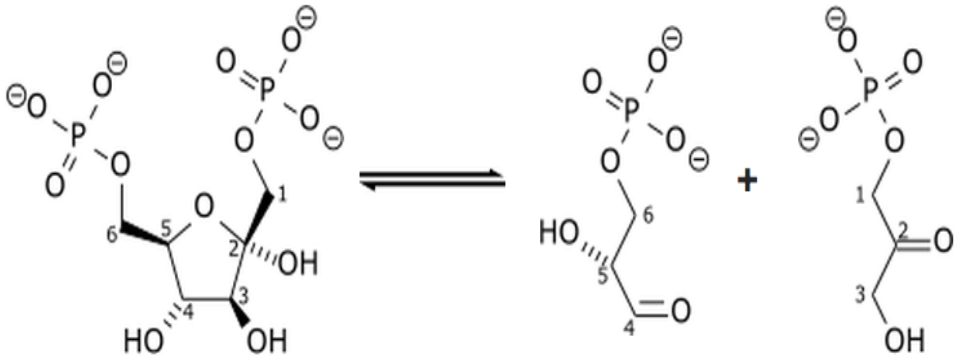
3. **Phosphorylation #2**
    - The hydroxyl group on carbon 1 is phosphorylated by ATP (catalyzed by **phosphofructokinase**)




Fructose 6-phosphate Fructose 1,6-bisphosphate

**4. Cleavage**

- Six carbon sugar is cleaved to produce two 3 carbon molecules



Fructose 1,6-bisphosphate

Glyceraldehyde 3-phosphate (G3P)

DHAP

**5. Second G3P Creation**

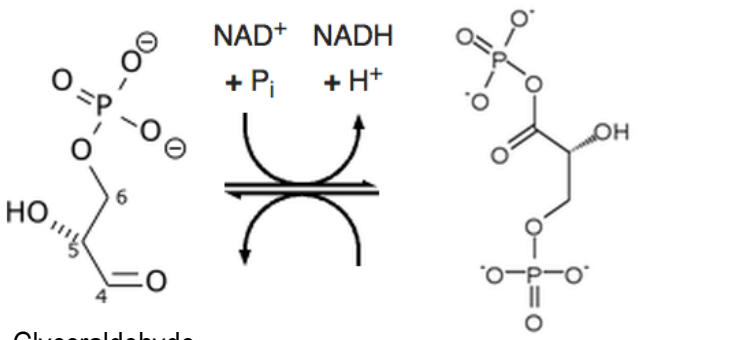
- DHAP is isomerized to form a second glyceraldehyde 3-phosphate

DHAP

Glyceraldehyde 3-phosphate (G3P)

6. **NADH Creation**

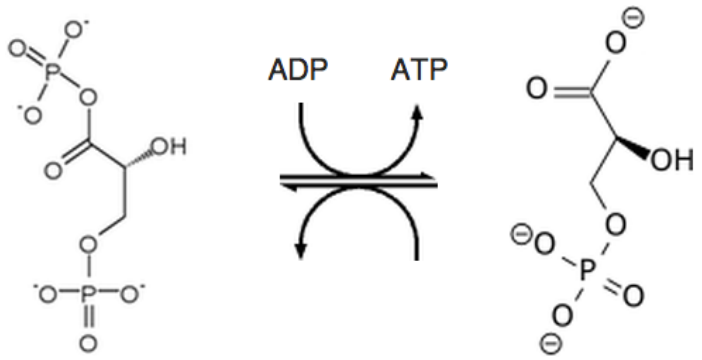
- Oxidation of both glyceraldehyde 3-phosphates creates NADH




Glyceraldehyde 3-phosphate (G3P)

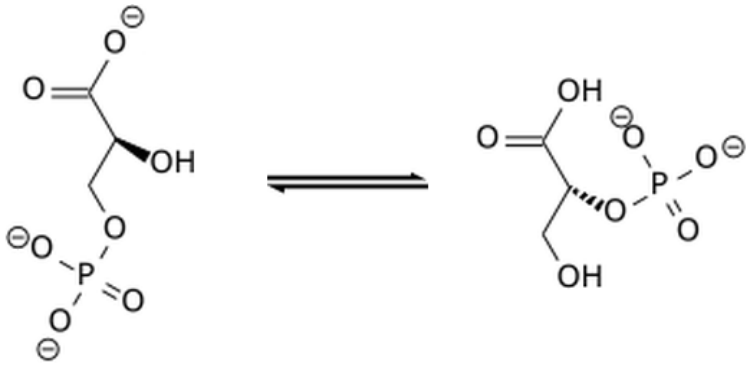
1,3-bisphosphoglycerate

7. **ATP creation**
    - Phosphate group is transferred to ADP to form ATP
    - **Substrate level phosphorylation:** ATP formation from transfer of phosphate from substrate to ATP




1,3-bisphosphoglycerate 3-phosphoglycerate

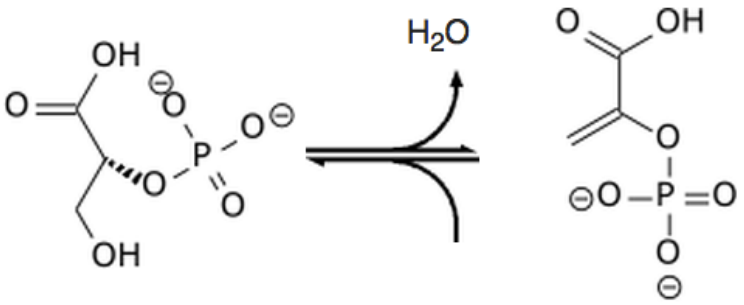
8. **Phosphate moved**
    - A phosphate is moved from carbon 3 to carbon 2 to form 2-phosphoglycerate



3-phosphoglycerate 2-phosphoglycerate

**9. Water Removal**

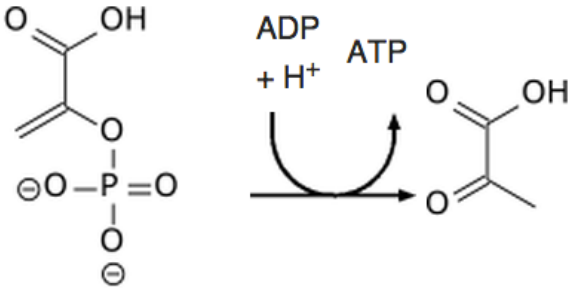
- Water is removed from 2-phosphoglycerate




2-phosphoglycerate Phosphoenolpyruvate (PEP)

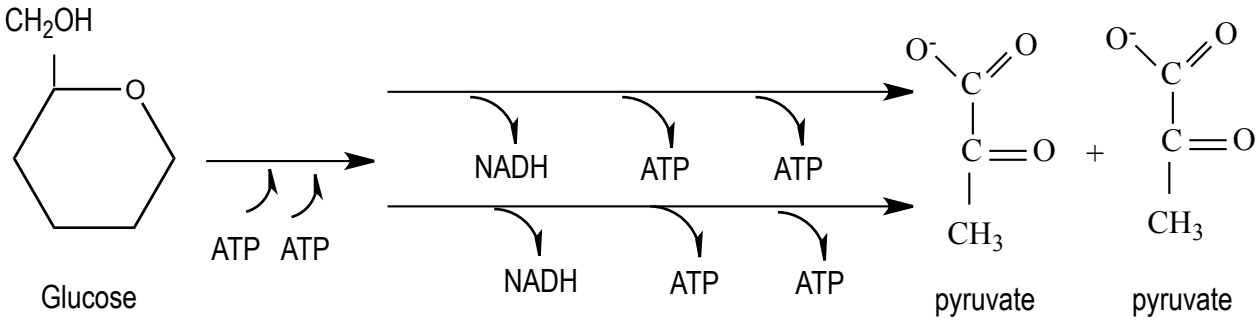
**10. ATP creation**

- A phosphate is transferred to ADP to form ATP




Phosphoenolpyruvate (PEP) Pyruvate

**EXAMPLE:** Net result of glycolysis




Glucose pyruvate pyruvate

**PRACTICE**

1. Which of the following is not a result of glycolysis?
    a. ATP
    b. Pyruvate
    c. NADPH
    d. NADH

2. Phosphofructokinase is an enzyme that is able to do what?
    a. Phosphorylate a molecule using a phosphate from ATP
    b. Breakdown ATP to provide energy to continue glycolysis
    c. Synthesize ATP
    d. Produce NADH

3. What happens during substrate level phosphorylation?
    a. ATP is broken down when it donates a phosphate to a molecule
    b. A phosphate is removed and used to synthesize ATP
    c. A G3P molecule is phosphorylated
    d. NADH is created

4. Which of the following enzymes is able to rearrange bonds within a molecule?
    a. Dehydrogenase
    b. Kinase
    c. Isomerase
    d. Mutase

5. An abundance of ATP causes what to happen to the rate of glycolysis?
    a. The rate of glycolysis speeds up
    b. The rate of glycolysis slows down
    c. The rate of glycolysis stays the same