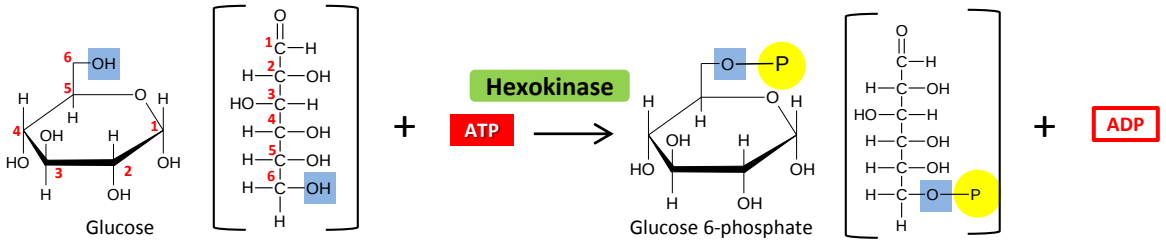
10 STEPS OF GLYCOLYSIS

For each step, the part of the molecule that actually changes is highlighted in blue. Enzymes that catalyze the reaction are highlighted in green. Although we recognize that sugars exist in a ring form within the cell, sugars are shown in brackets in their open chain form to assist visualization of the numbered carbons. Finally, note that the first 5 steps are "energy requiring". Energy will not be harvested until the steps on the next page.

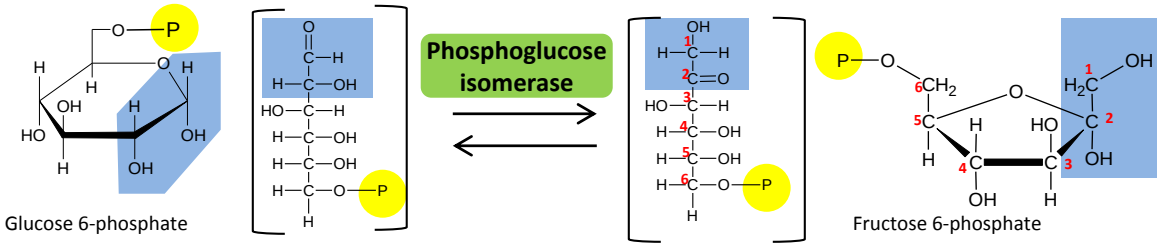
Step 1

Glucose enters the cell and ATP is used to phophorylate it. This fist step requires energy in the form of ATP. The polar nature of the phosphate group prevents passage of the Glucose back out of the cell.



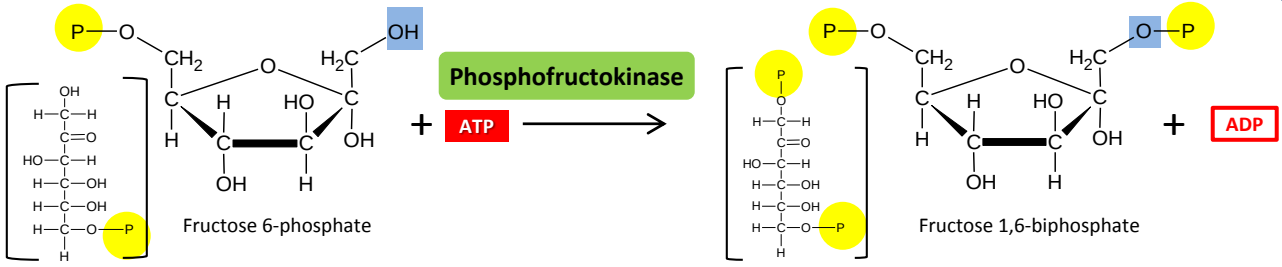
Step 2

A rearrangement of the chemical structure occurs. This is called isomerization and results in the movement of the carbonyl oxygen (C=O) from carbon 1 to carbon 2. This reaction is reversible.



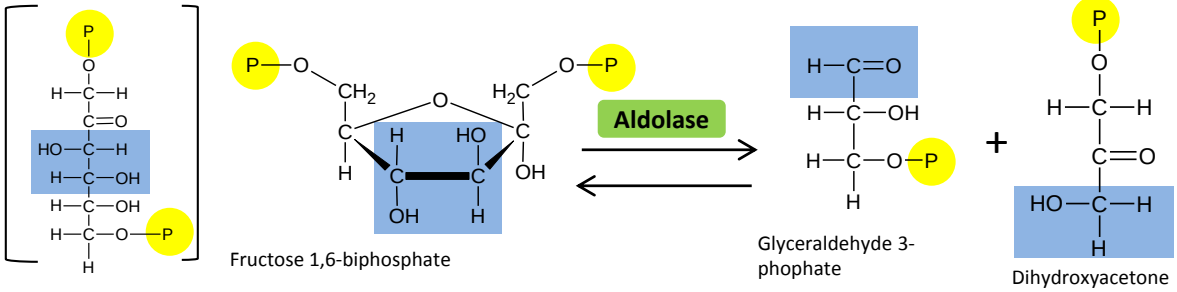
Step 3

The hydroxyl group (OH) on carbon 1 of fructose 6-phosphate is phosphorylated by ATP. This makes fructose 1,6-biphosphate. This is another step that requires energy in the form of ATP



Step 4

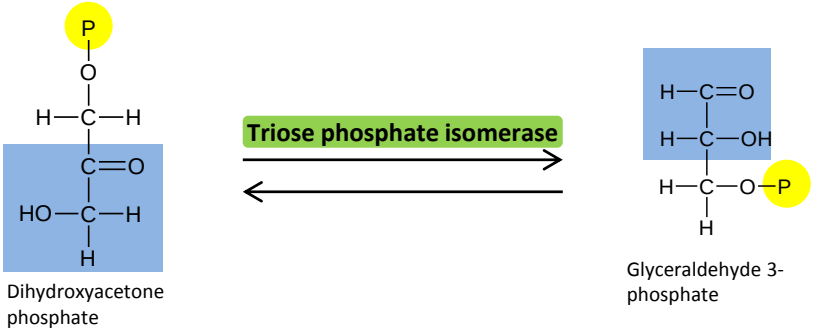
The six-carbon sugar called furctose that has been phosphorylated twice is cleaved to produce two 3 carbon molecules. Only Glyceraldehyde 3-phosphate can continue through the remaining steps of glycolysis.



Step 5

The other product from step 4 is called Dihydroxyacetone phosphate.

An isomerization reaction occurs to rearrange the chemical structure and create Glyeraldehyde 3-phosphate. Because of step 5, each of the products from step 4 ultimately continue through glycolysis as Glyceraldehyde 3 phosphate .

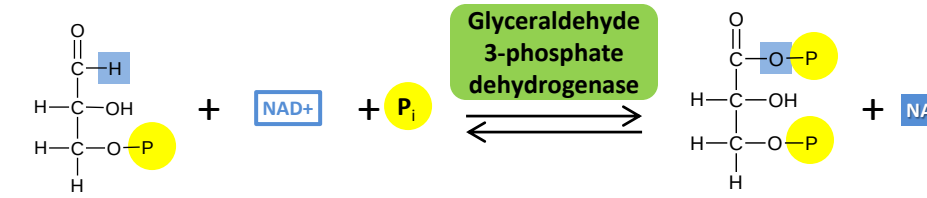


10 STEPS OF GLYCOLYSIS… CONT

****Don't forget that steps 6-10 happen TWICE. Once for each 3 carbon molecule generated in step 5****

Step 6

The aldehyde group of Glyceraldehyde 3-phosphate is dehydrogenated. The hydrogen with 2 electrons becomes part of NAD+ (becoming NADH). A phosphate is bonded at the number 1 carbon to make 1,3 -bisphosphoglycerate.



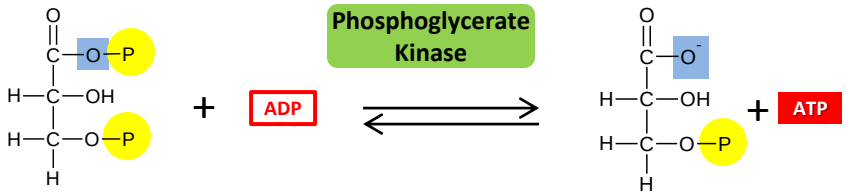
Glyceraldehyde 3-phosphate

1,3 - bisphosphoglycerate

** Note that this is the first step where energy is captured. High energy electrons with a hydrogen atom are captured onto NADH.

Step 7

A high energy phosphate from carbon 1 is transferred to ADP to form ATP. This is the first example of "substrate level phosphorylation".



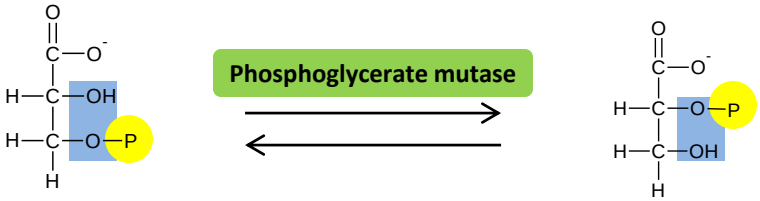
1,3 - bisphosphoglycerate

3-phosphoglycerate

** Note that energy is also captured here as ATP is manufactured directly. This is called substrate level phosphorylation.

Step 8

In preparation for step 09, the phosphate ester linkage at carbon 3 is removed and relocated at the number 2 carbon.

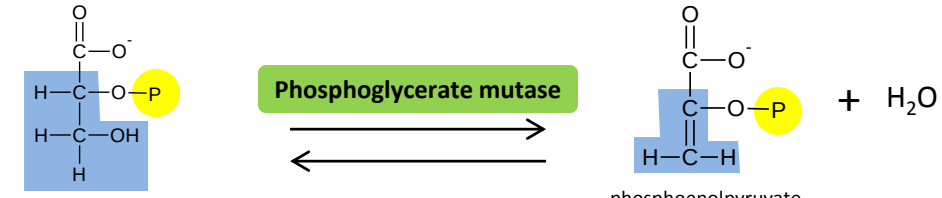


3-phosphoglycerate

2-phosphoglycerate

Step 9

A water molecule is removed from 2-phophoglycerate and as a result a double bond is formed between carbon 2 and 3. This creates a higher energy phosphate linkage.

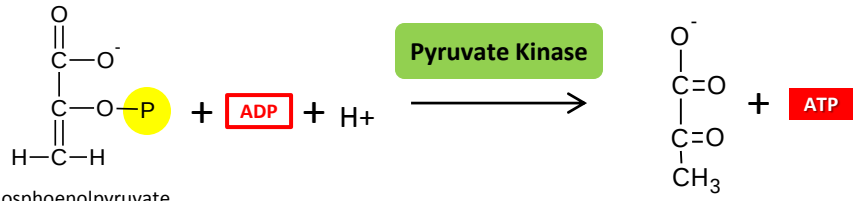


2-phosphoglycerate

phosphoenolpyruvate

Step 10

A phosphate group is transferred from the carbon 2 of phophenolpyrvate to ADP. This is another example of substrate level phosphorylation. The result is the final product of glycolysis called Pyruvate.

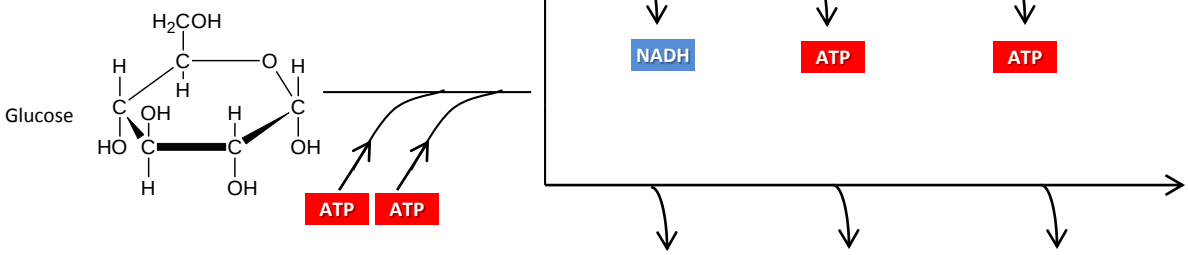


phosphoenolpyruvate

Pyruvate

** Note that energy is also captured here as ATP is manufactured directly. This is called substrate level phosphorylation.

Net Result of Glycolysis



2- Pyruvate

**So, although we "spend" energy from two ATP, we gain 4 ATP (So, a net gain of 2 ATP). We also gain 2 –NADH in this process of glycolysis. Pyruvate has more energy that can be harvested in the mitochondria. This is discussed next.