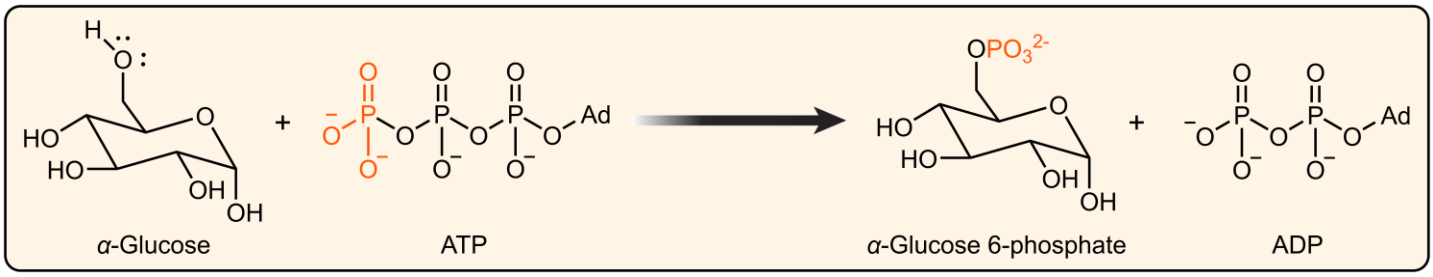
CONCEPT: CATABOLISM OF CARBOHYDRATES: GLYCOLYSIS

Glycolysis Reactions

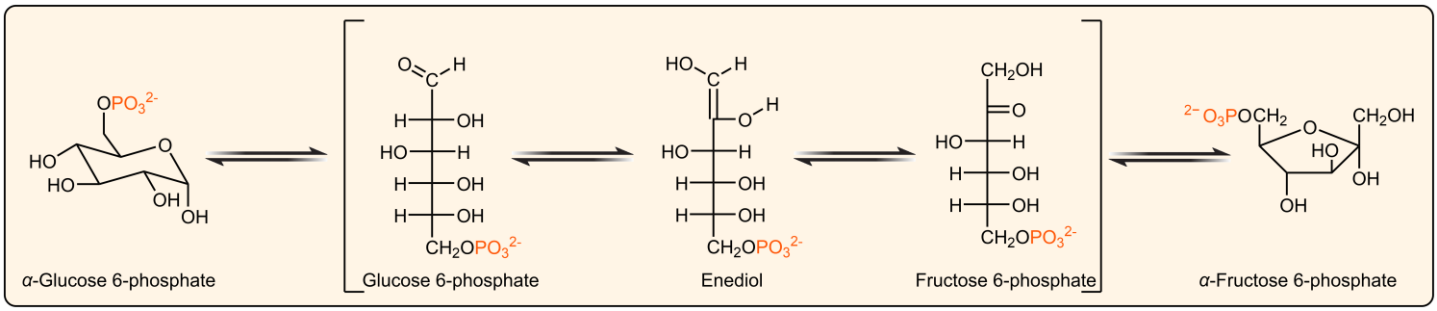
- Glycolysis is a sequence of ___ biochemical reactions.
  - □ Reactions ___ to ___ split 1 glucose molecule into 2 glyceraldehyde 3-phosphate (G3P) molecules.
  - □ Reactions ___ to ___ convert G3P to _____ and produce high-energy molecules (ATP and NADH).

1 Phosphorylation: C__ OH of *α*-glucose attacks the __-phosphorous of ATP.



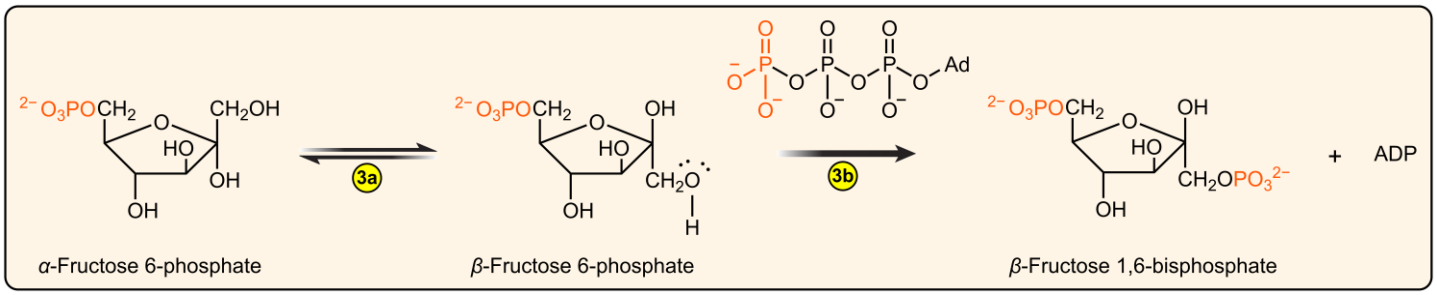
2 Isomerization: *α*-Glucose 6-phosphate isomerizes to *α*-fructose 6-phosphate.

- □ Isomerization takes place through an _____ intermediate.



3 Phosphorylation: *α*-Fructose 6-phosphate undergoes phosphorylation to yield *β*-fructose 1,6-bisphosphate.

3a Mutarotation occurs _____ phosphorylation. **3b** □ Phosphorylation occurs at C__ OH.



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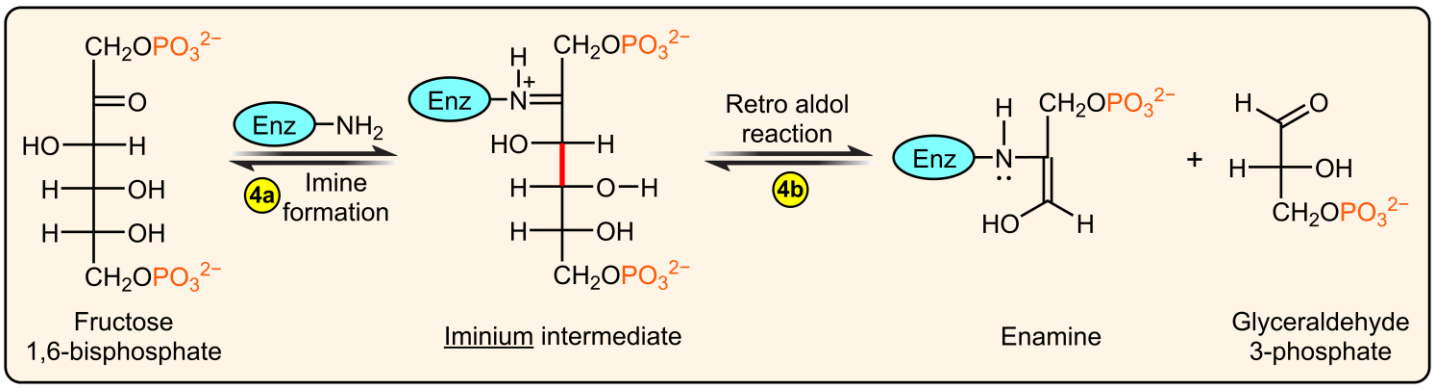
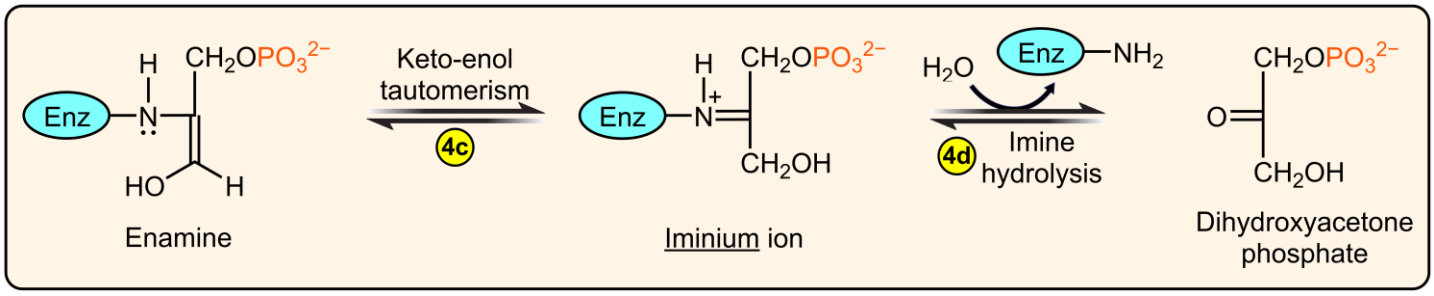
4 Bond Cleavage: Fructose 1,6-bisphophate undergoes a _____ _____ reaction.

4a An iminium intermediate is formed first. **4b** C__–C__ bond of the intermediate is cleaved.

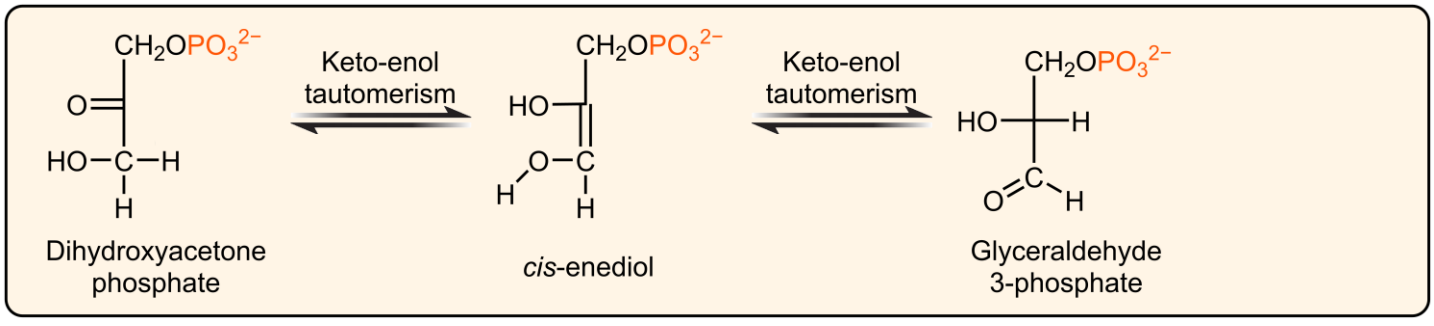


4c and **4d** Tautomerization and _____ of the enamine produces dihydroxyacetone phosphate (DHAP).



5 Isomerization: Dihydroxyacetone phosphate (DHAP) is isomerized to glyceraldehyde-3-phosphate (G3P).

□ Occurs via _____ mechanism.



EXAMPLE: Identify the mechanism through which DHAP is converted into G3P.

a) Phosphorylation

b) Enediol mechanism

c) E1cB elimination

d) Dehydration

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PRACTICE: Classify each one of the following reactions as phosphorylation (P), isomerization (I), or neither (N).

a) ____ Conversion of glucose into glucose-6-phosphate.

b) ____ Conversion of glucose-6-phosphate into fructose-6-phosphate.

c) ____ Conversion of DHAP into G3P.

d) ____ Cleavage of fructose-1,6-bisphosphate into DHAP and G3P.

PRACTICE: Which one of the following compound pairs is produced by cleavage of fructose-1,6-bisphosphate?

a) Dihydroxyacetone phosphate and glyceraldehyde-3-phosphate

b) glyceraldehyde-3-phosphate and glyceraldehyde-2-phosphate

c) Glyceraldehyde-3-phosphate and CO_2

d) Dihydroxyacetone phosphate and 3-phosphoglycerate

PRACTICE: Identify which carbon atoms of fructose 1,6-bisphosphate become carbonyl groups in dihydroxyacetone phosphate and glyceraldehyde 3-phosphate when it undergoes a retro aldol reaction in step 4 of glycolysis.

a) C3 and C4

b) C2 and C5

c) C3 and C5

d) C2 and C4

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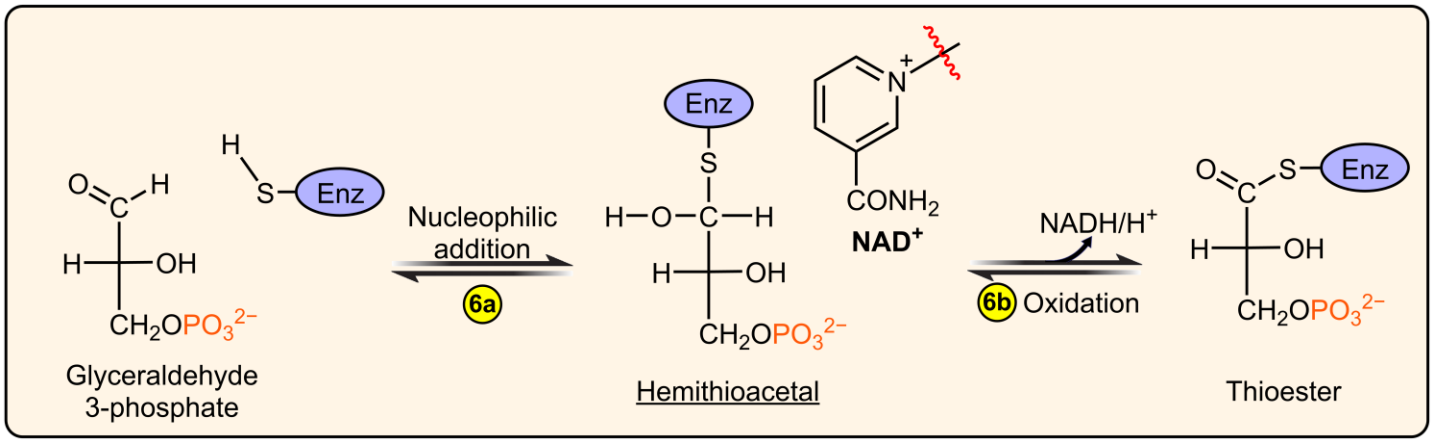
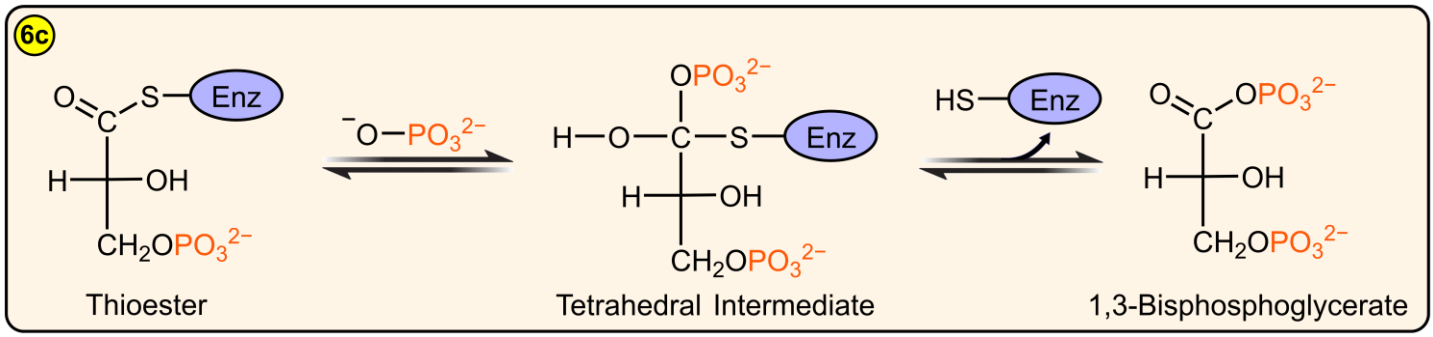
6 Oxidation × 2: G3P undergoes oxidation to produce 1,3-bisphosphoglycerate (1,3_____).

6a A hemithioacetal is formed first.

6b NAD^+ _____ produces a thioester.

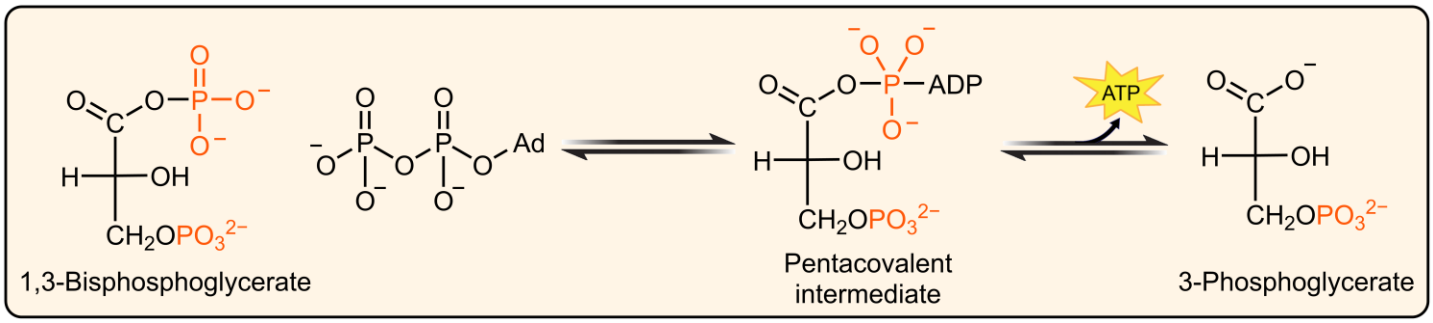


6c The thioester undergoes an _____ reaction with the phosphate ion.



7 Phosphate Transfer × 2: 1,3BPG produces 3-phosphoglycerate (3PG) by losing a _____ group.

□ Occurs via _____ mechanism.



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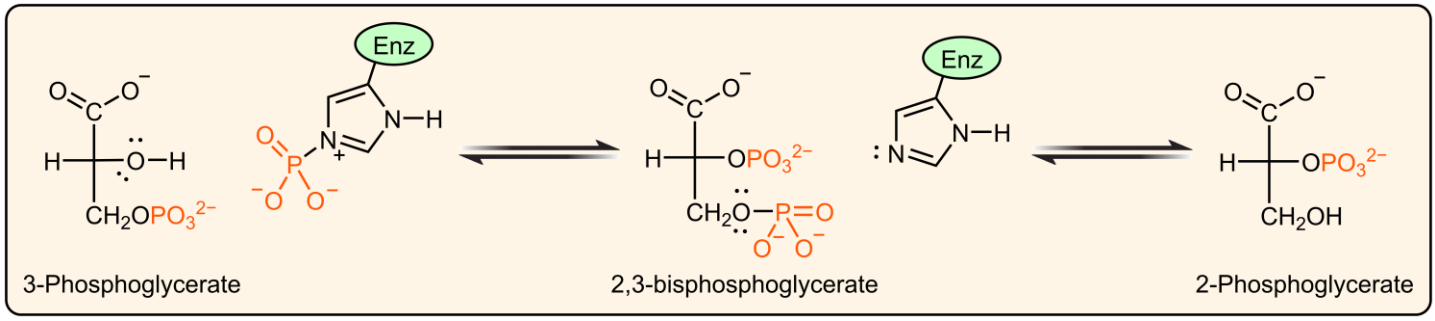
8 Isomerization × 2: 3-phosphoglycerate (3PG) undergoes isomerization to yield 2-phosphoglycerate (2PG).

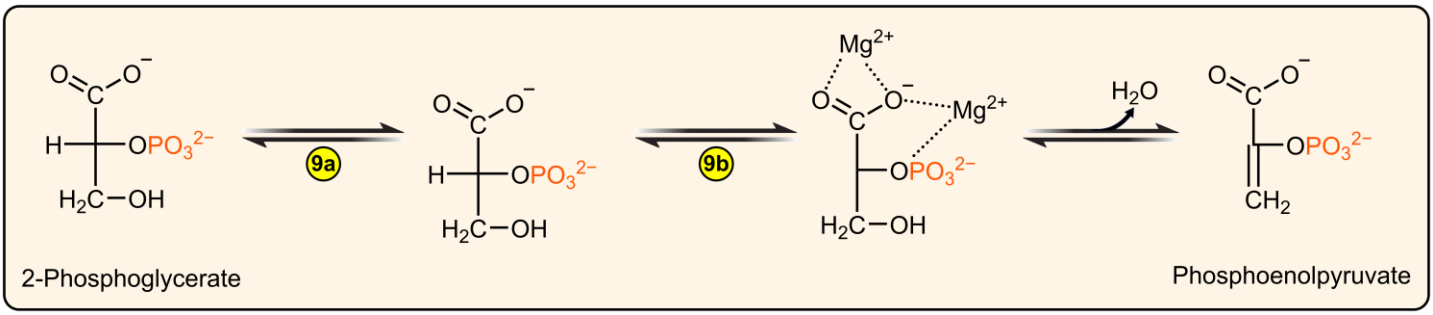
□ Occurs via __ _____ reactions.



9 Dehydration × 2: 2-phosphoglycerate (2PG) undergoes dehydration to produce phosphoenolpyruvate (PEP).

9a Mg^{2+} ions are required to reduce __ charges.

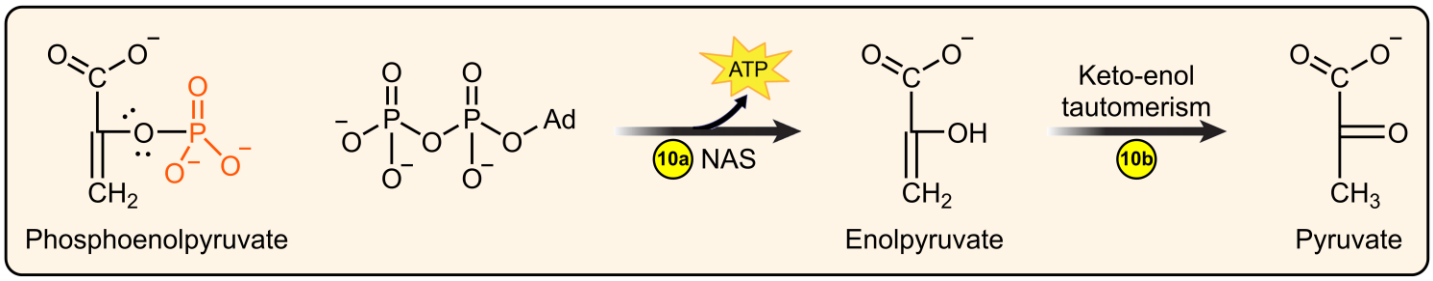
9b Dehydration occurs via _____ mechanism.



10 Phosphate Transfer × 2: PEP yields pyruvate by losing its _____ group.

10a NAS reaction with ADP produces enolpyruvate.

10b Tautomerization produces pyruvate.



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EXAMPLE: Which one of the following glycolysis reactions will produce an ATP molecule?

a) 3-Phosphoglycerate to 2-phosphoglycerate

b) Glyceraldehyde-3-phosphate to 1,3-Bisphosphoglycerate

c) Glucose to glucose-6-phosphate

d) 1,3-Bisphosphoglycerate to 3-phosphoglycerate

PRACTICE: Identify the mechanism for each of the following reactions as NAS, E1cB, or S_N2.

a) ____ Dehydration of 2-phosphoglycerate to produce phosphoenolpyruvate.

b) ____ Conversion of 1,3-bisphosphoglycerate into 3-phosphoglycerate.

c) ____ Conversion of glucose into glucose-6-phosphate.

d) ____ Conversion of 3-phosphoglycerate into 2-phosphoglycerate.

PRACTICE: If the P atom in 3-phosphoglycerate is labelled with phosphorous-32, where does the label end up after it is isomerized to 2-phosphoglycerate in step 8 of glycolysis?

a) Ends up as the phosphate group in 2-phosphoglycerate.

b) Ends up as free phosphate group because it is exchanged with a free phosphate from the solution outside the enzyme.

c) On the histidine residue of the enzyme that catalyzes the reaction.

d) Ends up as the *γ*-phosphate group of ATP that's produced in the reaction.