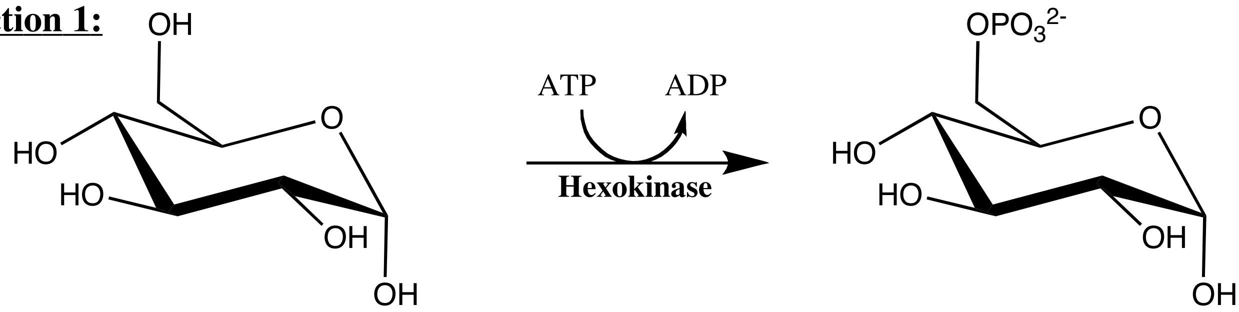
Glycolysis

Stage I: Energy Investment

<u>Reaction 1:</u>



Glucose

Glucose-6-Phosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

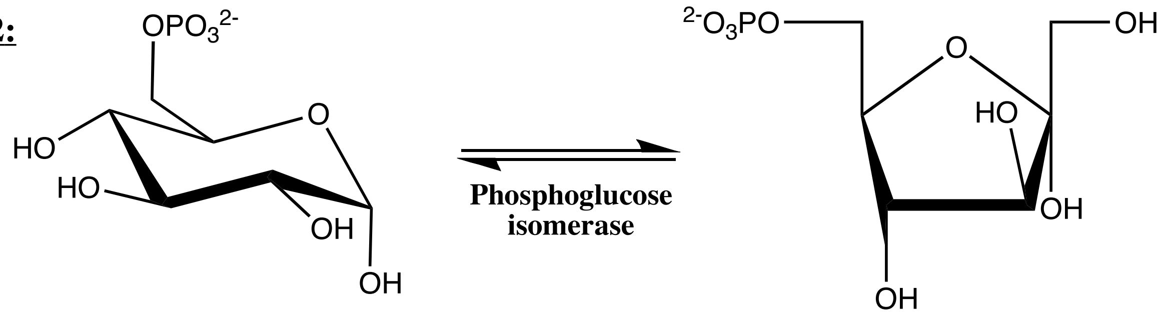
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

<u>Reaction 2:</u>



Glucose-6-Phosphate   Fructose 6-Phosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

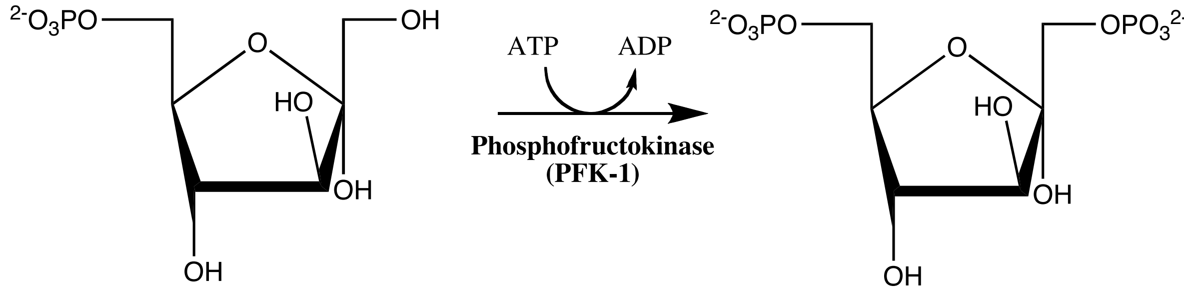
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 3:



Fructose 6-Phosphate

Fructose 1,6-Bisphosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

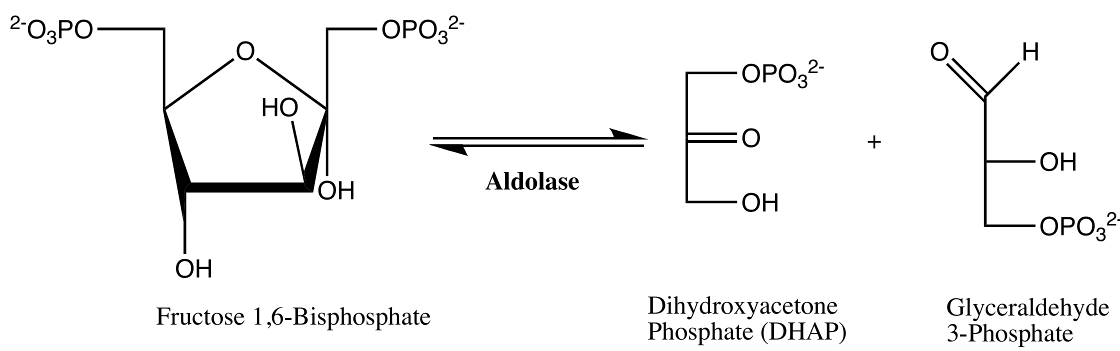
$\Delta G°'$ (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 4:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

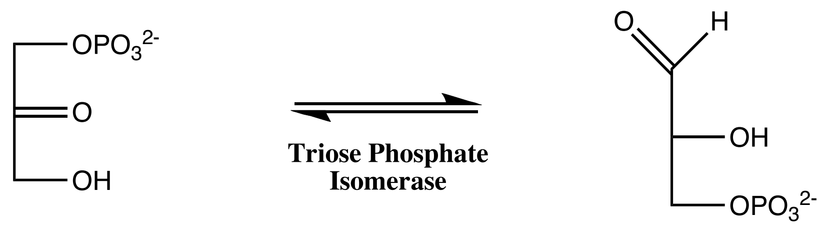
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 5:



Dihydroxyacetone Phosphate (DHAP)

Glyceraldehyde 3-Phosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

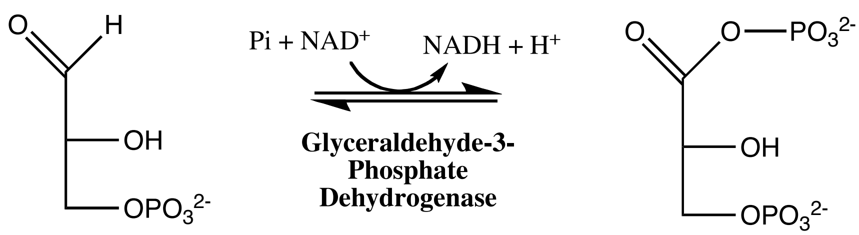
Purpose of reaction:

Regulation (if yes, how?):

Stage II: Energy Recapture

From this point forward, there are **TWO** molecules reacting at each step (as derived from glucose).

Reaction 6:



Glyceraldehyde 3-Phosphate

Glycerate-1,3-Bisphosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

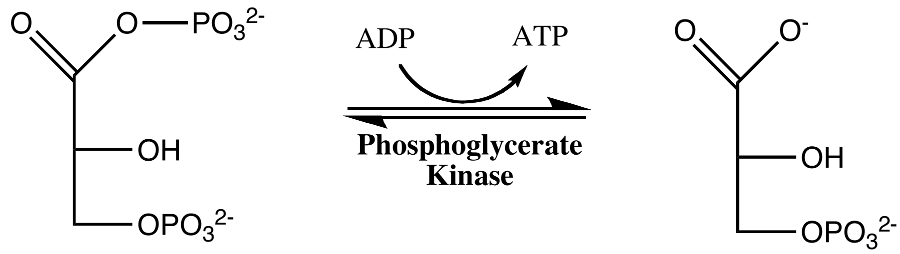
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 7:



Glycerate-1,3-Bisphosphate

3-Phosphoglycerate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

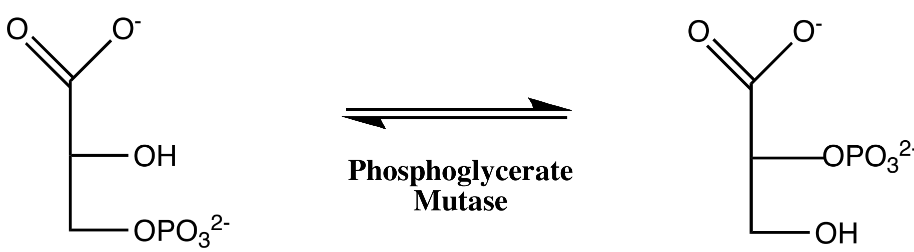
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 8:



3-Phosphoglycerate

2-Phosphoglycerate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

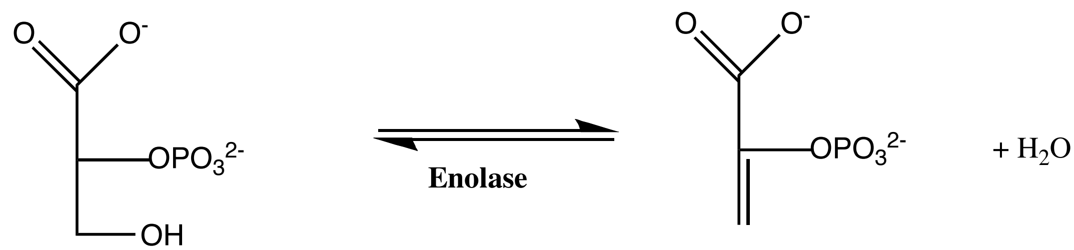
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

<u>Reaction 9:</u>



2-Phosphoglycerate

Phosphoenolpyruvate (PEP)

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

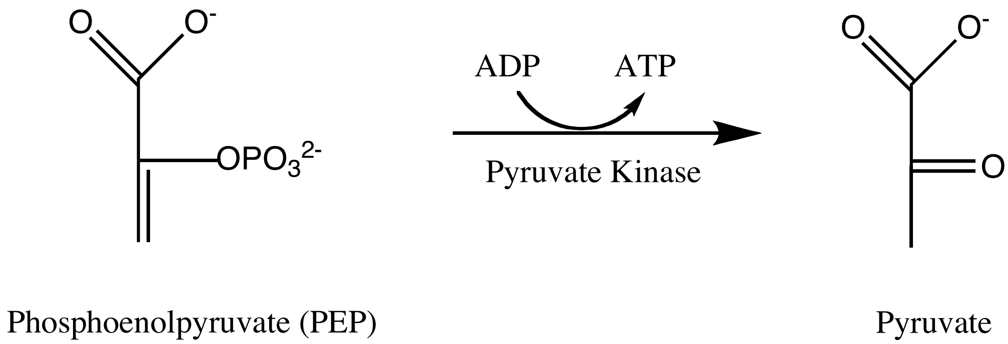
$\Delta G^{\circ\prime}$ (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 10:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

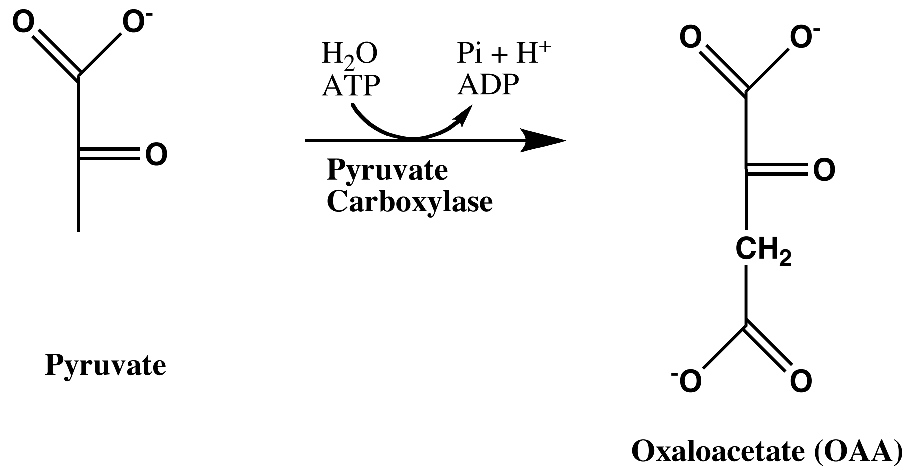
Purpose of reaction:

Regulation (if yes, how?):

Gluconeogenesis-Bypass Reactions

Bypass I:

Reaction 1:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

ΔG°' (reversible/irreversible?):

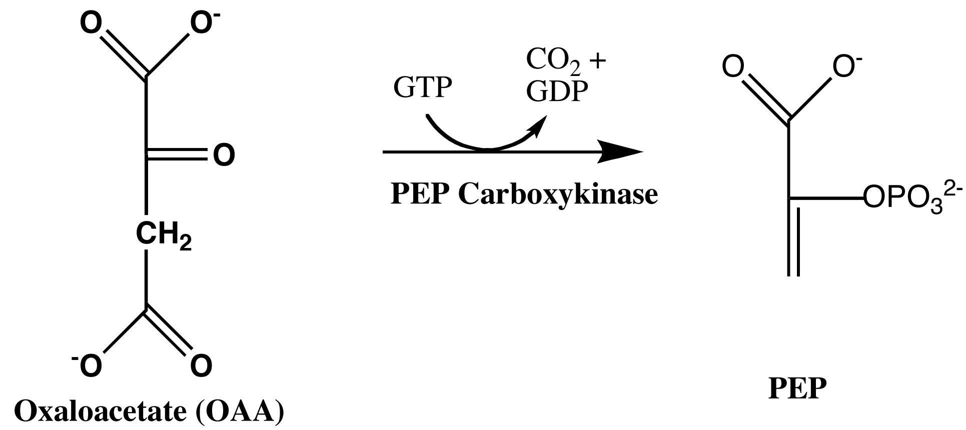
Energy Input/Output (ATP equiv.):

Purpose of reaction:

Location:

Regulation (if yes, how?):

Reaction 2:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

ΔG°' (reversible/irreversible?):

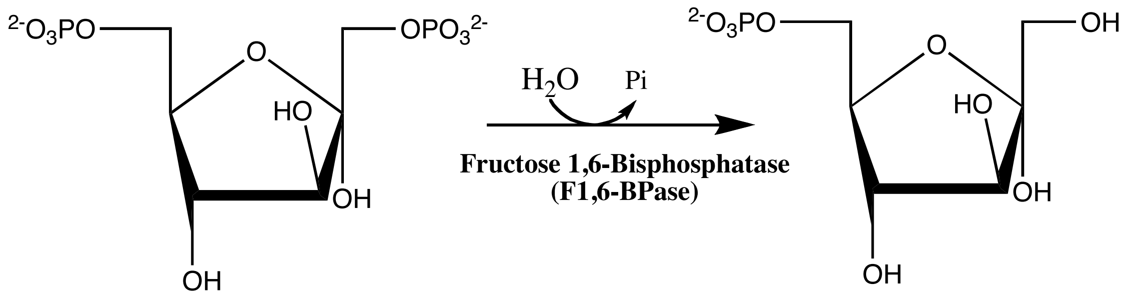
Energy Input/Output (ATP equiv.):

Purpose of reaction:

Location:

Regulation (if yes, how?):

Bypass II:



Fructose 1,6-Bisphosphate

Fructose 6-Phosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

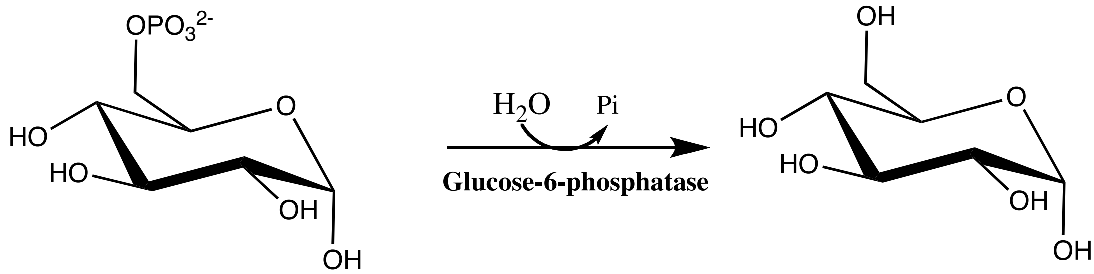
$\Delta G°'$ (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Bypass III:



Glucose-6-Phosphate

Glucose

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

$\Delta G^{\circ\prime}$ (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

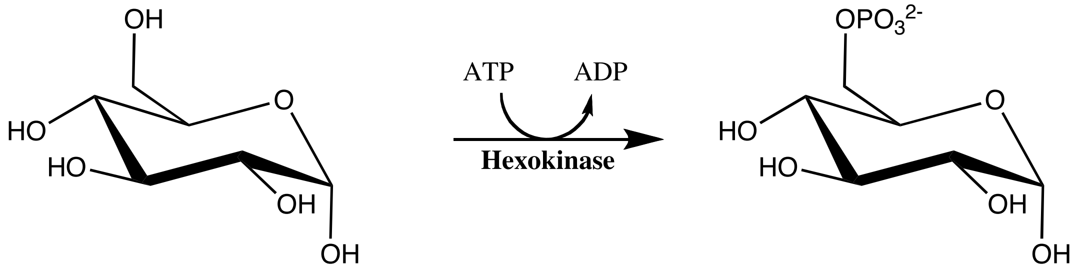
Purpose of reaction:

Location:

Regulation (if yes, how?):

Glycogenesis

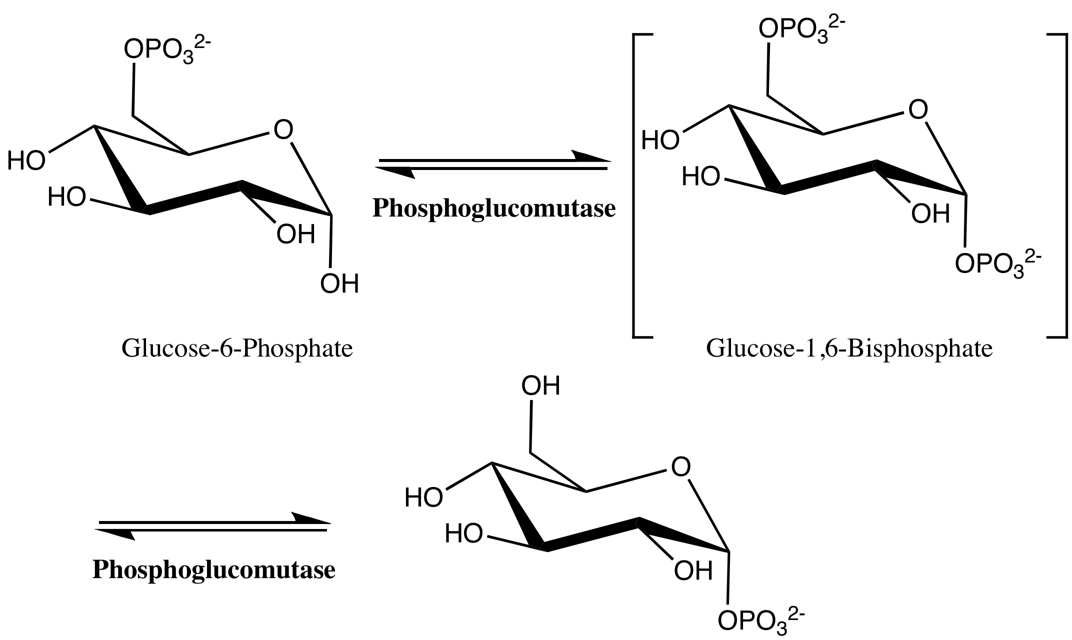
Reaction 1:



Glucose

Glucose-6-Phosphate

Reaction 2:



Glucose-1-Phosphate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

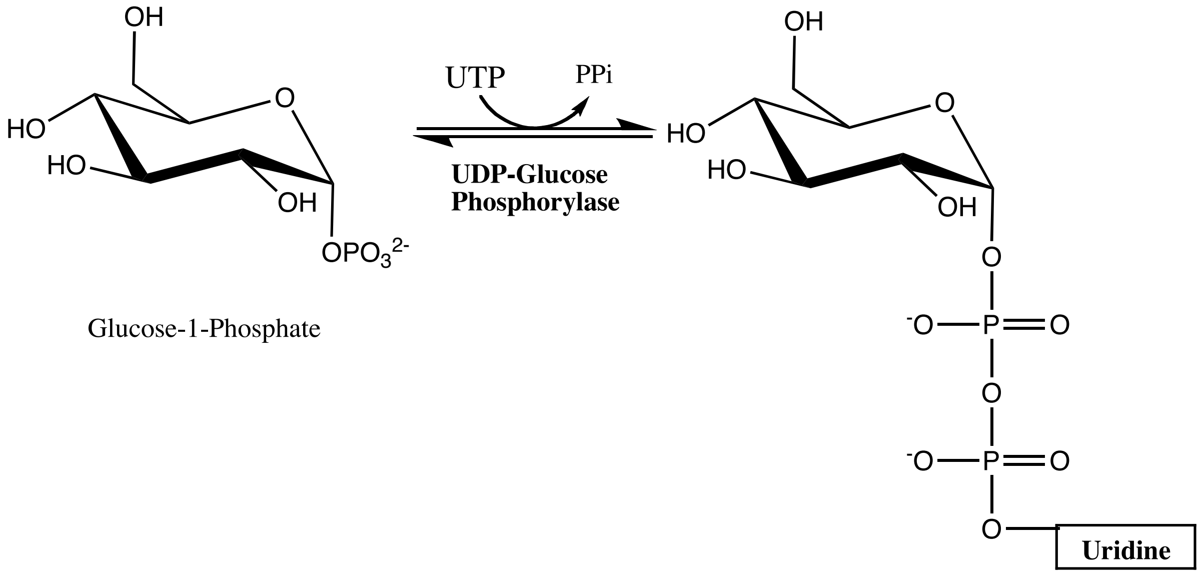
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 3:



Glucose-1-Phosphate

UDP-Glucose

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

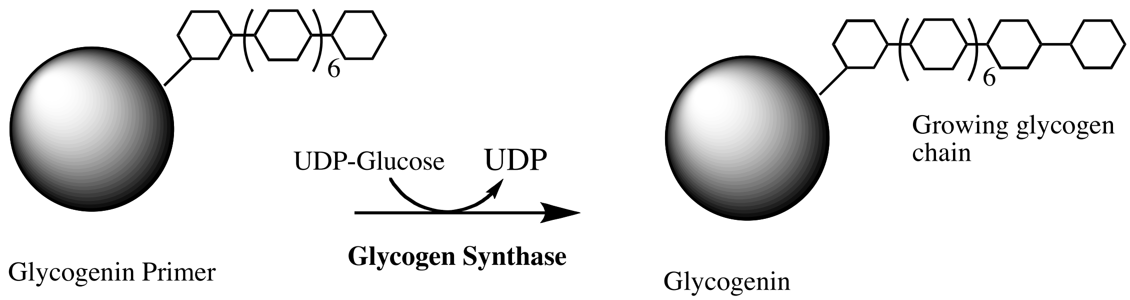
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 4:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

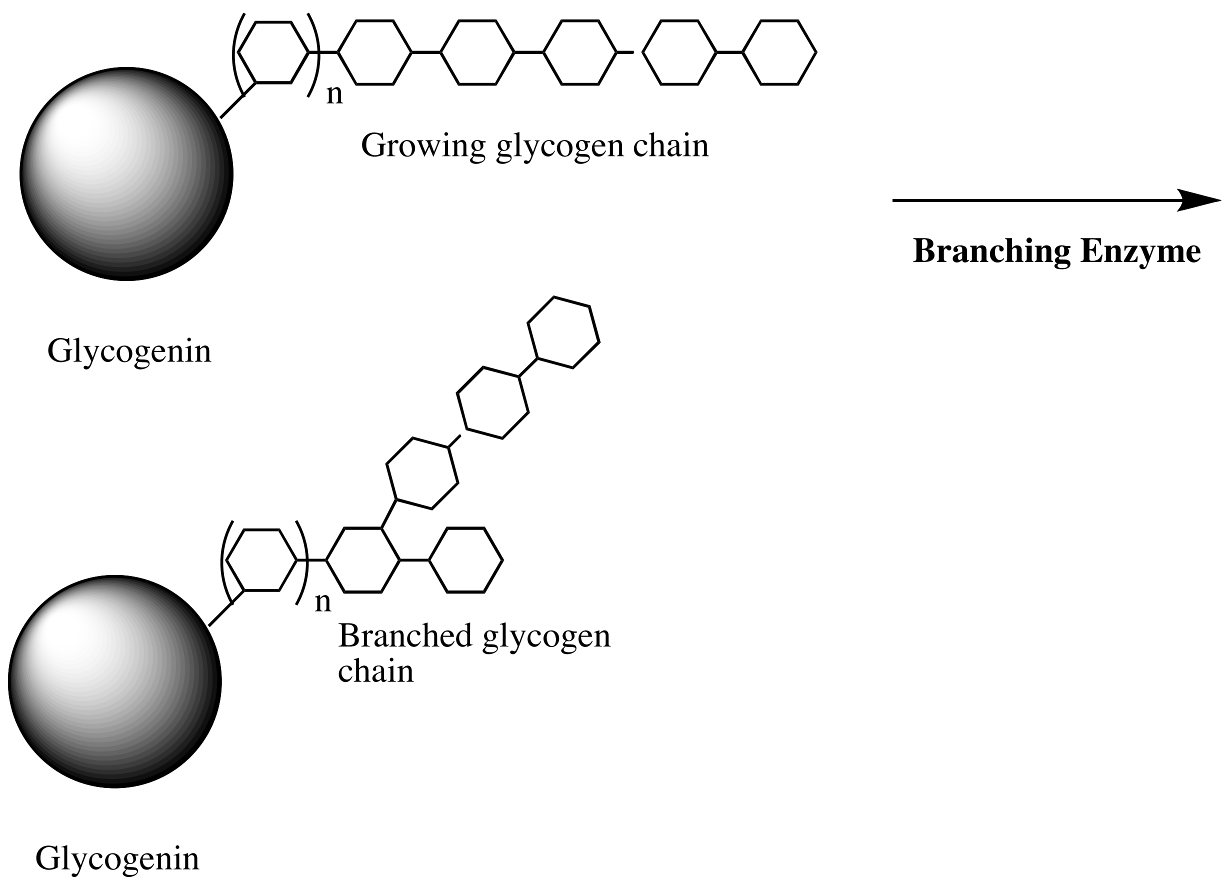
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 5:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

$\Delta G^{\circ\prime}$ (reversible/irreversible?):

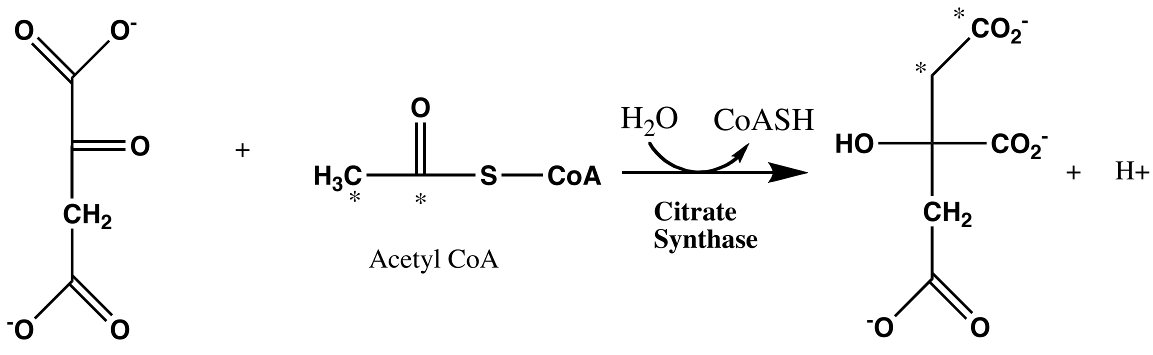
Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Citric Acid Cycle

<u>Reaction 1:</u>



Oxaloacetate (OAA)

Citrate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

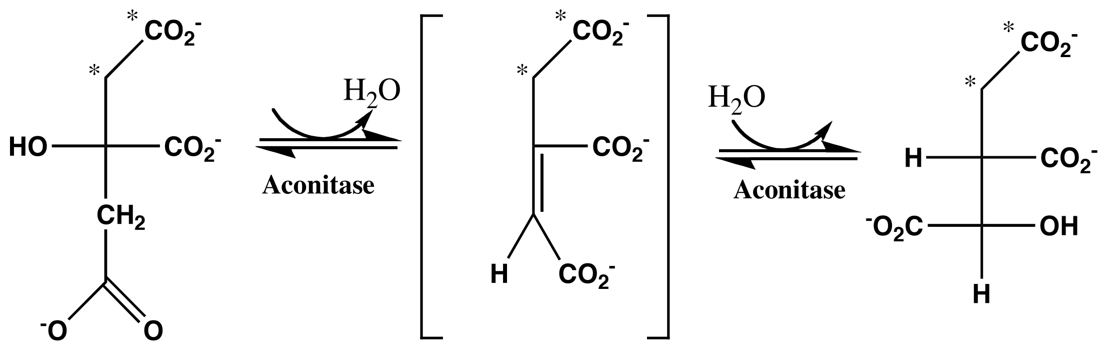
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 2:



Citrate cis-Aconitate Isocitrate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

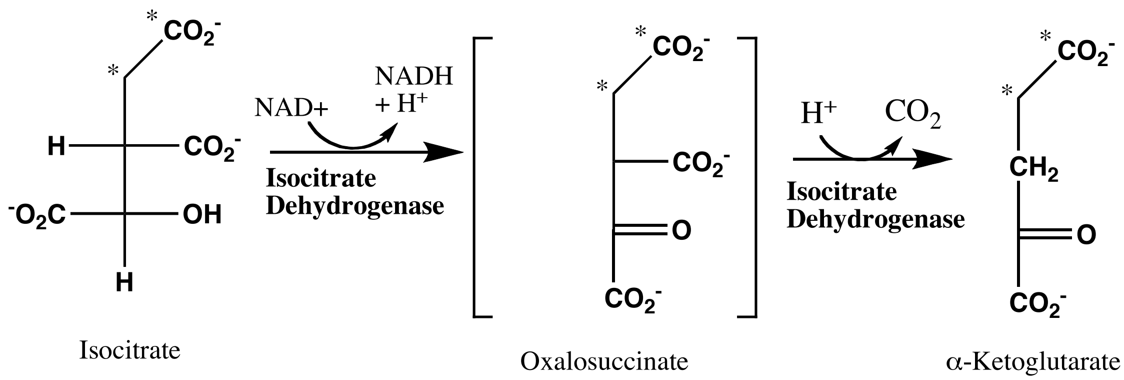
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 3:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

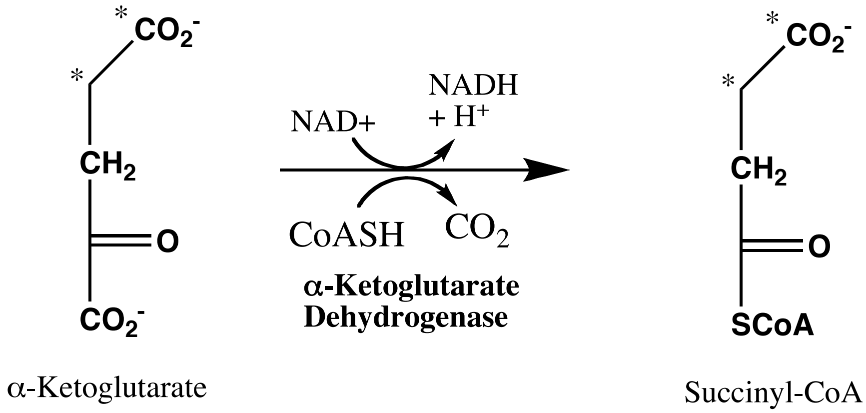
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 4:



Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

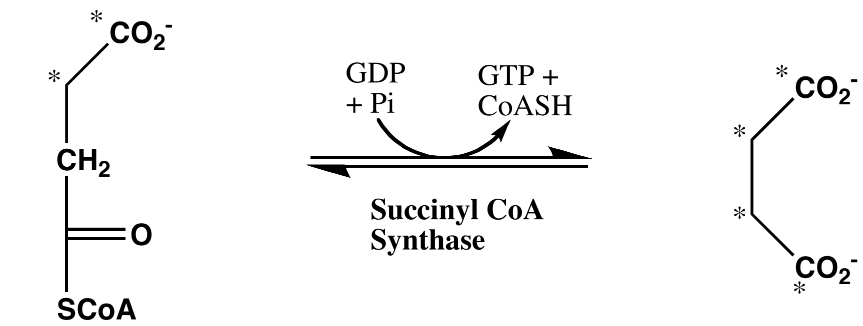
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 5:



Succinyl-CoA

Succinate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

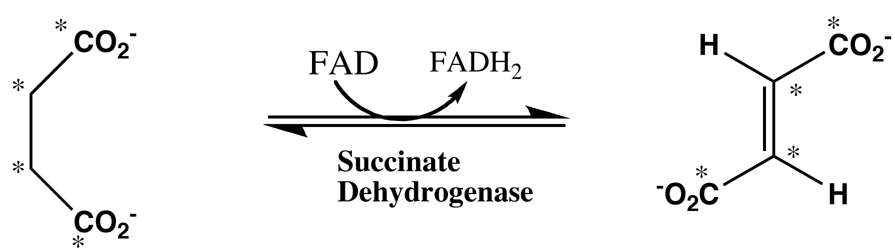
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 6:



Succinate

Fumarate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

ΔG°' (reversible/irreversible?):

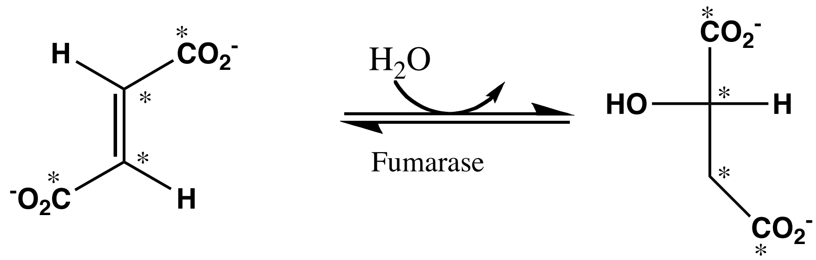
Energy Input/Output (ATP equiv.):

Purpose of reaction:

Location:

Regulation (if yes, how?):

Reaction 7:



Fumarate   Malate

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

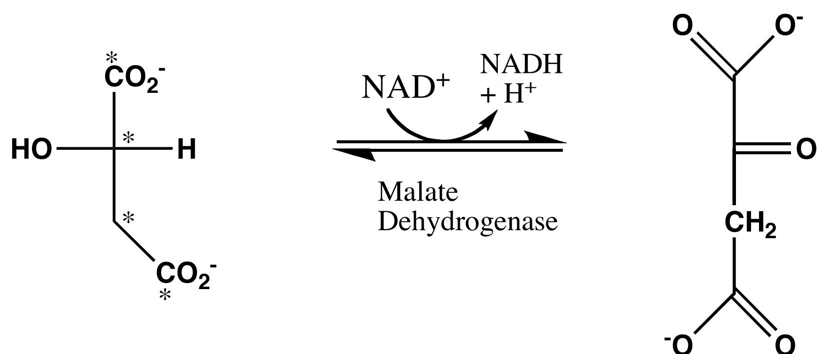
ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Reaction 8:



Malate

Oxaloacetate (OAA)

Reaction Type/Enzyme Class:

Cofactors/Coenzymes:

ΔG°' (reversible/irreversible?):

Energy Input/Output (ATP equiv.):

Purpose of reaction:

Regulation (if yes, how?):

Additional Study Questions for Chapters 8 and 9

1. Why must NADH produced in glycolysis be oxidized to regenerate NAD+, regardless of whether the system as a whole is aerobic or anaerobic?

2. How would a low concentration of Mg+2 in red blood cells affect the rate of glycolysis? Why?

3. A thiamine deficiency would have what effect on the activity of pyruvate dehydrogenase?

4. In mitochondria supplied with pyruvate, which of the following conditions would give maximal CAC activity? Why?

   High [ADP], high [NADH], high [acetyl CoA]
   High [ATP], low [NAD], high [acetyl CoA]
   High [ADP], high [NAD], low [acetyl CoA]
   High [ADP], high [NAD], high [acetyl CoA]

5. Briefly describe the biological rationale for each of the following allosteric regulation events: a. activation of pyruvate carboxylase by acetyl CoA b. activation of pyruvate dehydrogenase kinase by NADH c. inhibition of isocitrate dehydrogenase by ATP d. activation of isocitrate dehydrogenase by ADP e. inhibition of α-ketoglutarate dehydrogenase complex by succinyl CoA f. activation of pyruvate dehydrogenase complex by AMP

6. Compare the ratios of NADH/NAD+ and ATP/ADP in heart muscle during periods of sleep and jogging.

7. AMP serves as an activator of the pyruvate dehydrogenase complex. Why is this metabolically desirable?

8. Succinyl CoA and citrate both inhibit the enzymes involved in their own synthesis. Name this type of inhibition.

9. None of the reactants of the citric acid cycle requires oxygen as a reactant. Why, then, does the citric acid cycle constitute an aerobic pathway?

10. In response to low levels of glucose in the blood, the pancreas produces glucagon which triggers the adenylyl cyclase signaling pathway in liver cells. As a result, flux through glycolysis slows. Why is it advantageous for glycolysis to decrease in the liver in response to low blood glucose levels?

11. In three separate experiments, pyruvate labeled with 14C at C-1, C-2, or C-3 is metabolized via the pyruvate dehydrogenase complex and the CAC. Which labeled pyruvate yields the first 14C? Which yields the last?

12. What are the functions of each of the 5 coenzymes utilized in the pyruvate dehydrogenase and α-ketoglutarate dehydrogenase complexes?

13. Explain why the reaction catalyzed by PFK-1 is the main regulatory site for glycolysis and not the reaction catalyzed by hexokinase that occurs earlier in the pathway.

14. How is the activity of PFK-1 regulated?

15. Explain why fructose 1,6-bisphosphate stimulates pyruvate kinase. What kind of activation does this represent?

16. Explain the necessity of glycogen being a highly branched, rather than a linear polysaccharide.

17. Why is it important that the enzymes that catalyze the regulatory steps of glycolysis and gluconeogenesis not be catalyzed by the same enzymes, yet have the same reactants/products?

18. If pyruvate carboxylase is in the mitochondria and the next enzyme in the process, PEP carboxykinase is in the cytosol, how is it possible for the product of pyruvate carboxylase, oxaloacetate to get to PEP carboxykinase if it cannot cross the mitochondrial membrane?

19. Explain how PEP, succinyl CoA, and glycerate 1,3-bisphosphate constitute molecules with high phosphate transfer potential?

20. What is the purpose of converting glucose 1-phosphate to UDP-glucose in glycogenesis?