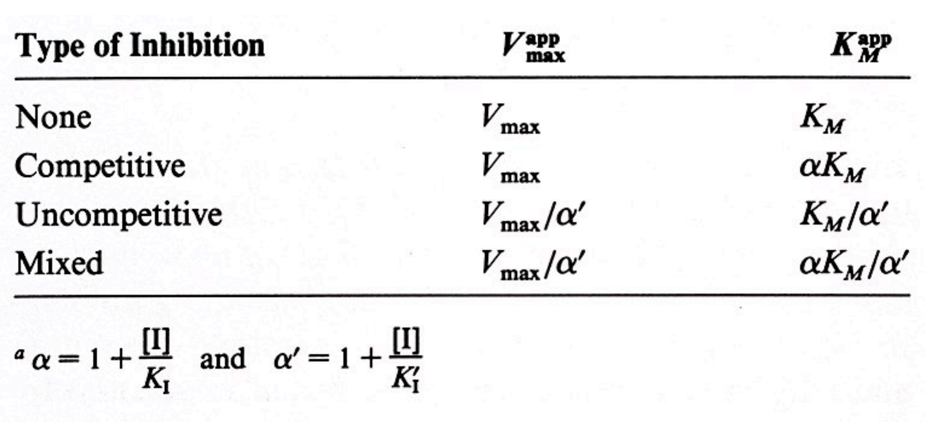
Effects of inhibitors on V_{max} and the “apparent” K_M



Type of Inhibition	V_{max}^{app}	K_M^{app}
None	V_{max}	K_M
Competitive	V_{max}	αK_M
Uncompetitive	V_{max}/α'	K_M/α'
Mixed	V_{max}/α'	$\alpha K_M/\alpha'$

[a] $\alpha = 1 + \frac{[I]}{K_I}$ and $\alpha' = 1 + \frac{[I]}{K'_I}$

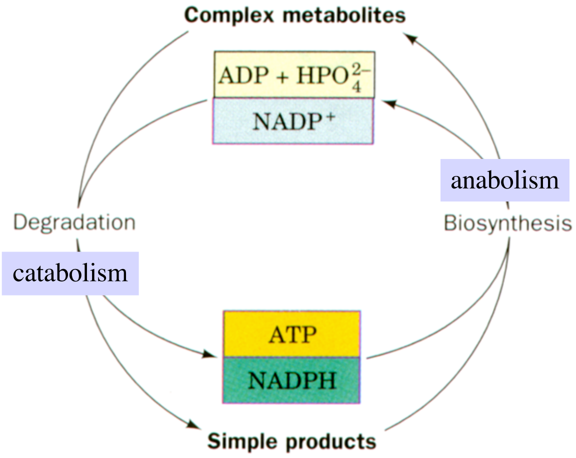
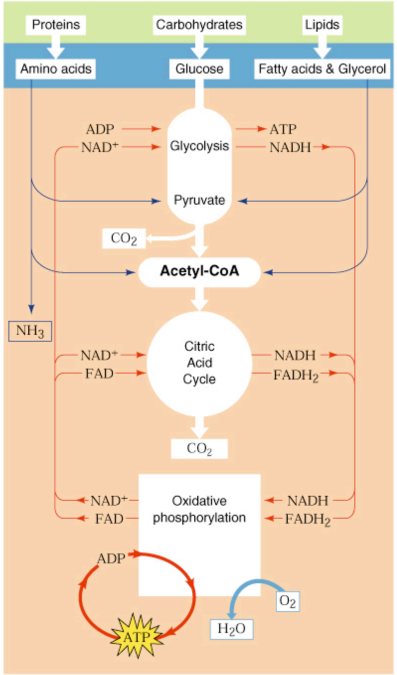
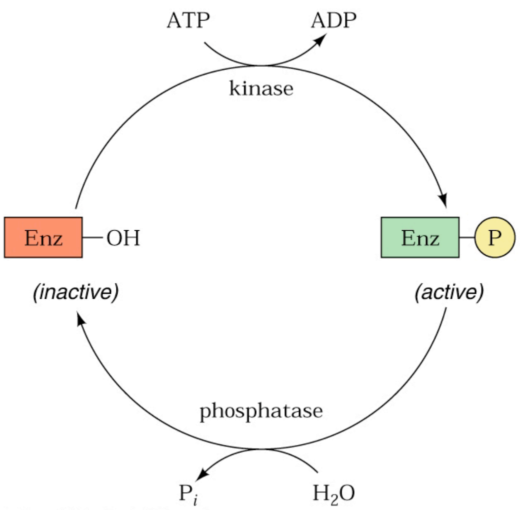


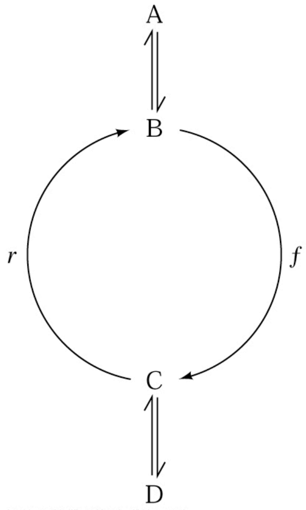
Figure 13-1. Roles of ATP and NADP$^+$ in metabolism.

Fig. 13.2:

Overview of Catabolism







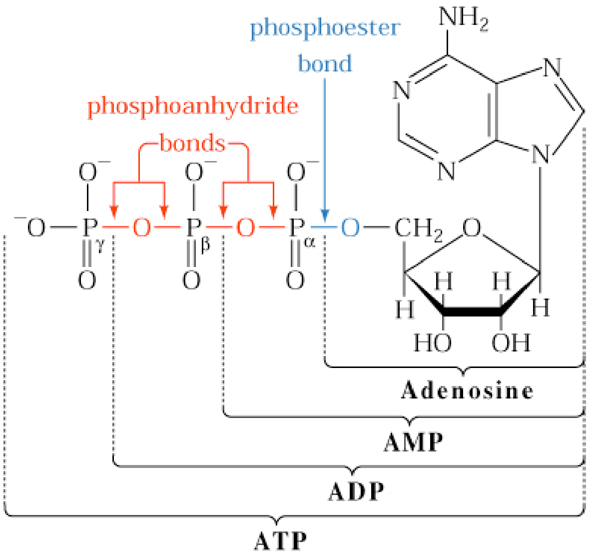


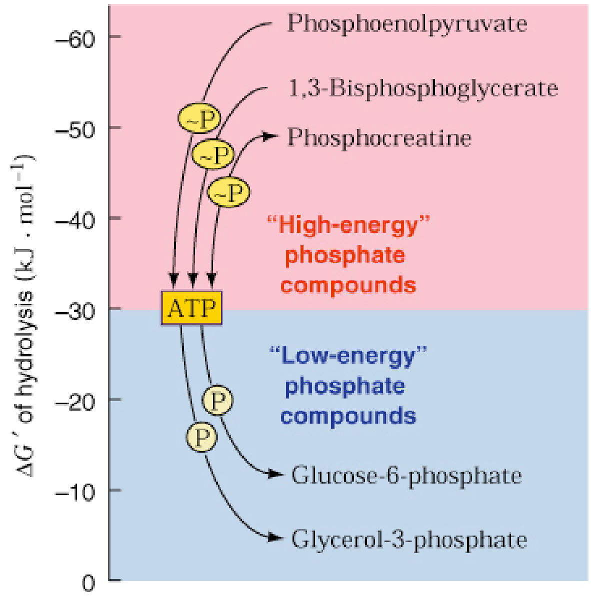
Fig. 13-3: The structure of ATP indicating its relationship to ADP, AMP, and adenosine.

Table 13-2. Standard Free Energies of Phosphate Hydrolysis of Some Compounds of Biological Interest

Compound	$\Delta G^{\circ\prime}$ ($kJ \cdot mol^{-1}$)
Phosphoenolpyruvate	−61.9
1,3-Bisphosphoglycerate	−49.4
Acetyl phosphate	−43.1
Phosphocreatine	−43.1
PP_i	−33.5
ATP (→ AMP + PP_i)	−32.2
ATP (→ ADP + P_i)	−30.5
Glucose-1-phosphate	−20.9
Fructose-6-phosphate	−13.8
Glucose-6-phosphate	−13.8
Glycerol-3-phosphate	−9.2

Source: Jencks, W.P., *in* Fasman, G.D. (Ed.), *Handbook of Biochemistry and Molecular Biology* (3rd ed.), Physical and Chemical Data, Vol. I, pp. 296–304, CRC Press (1976).

Fig. 13-7: Position of ATP relative to "high-energy" and "low-energy" phosphate compounds.



The free energy of ATP hydrolysis inside cells is determined in part by the concentrations of ATP, ADP, and Pi.

$$\Delta G = \Delta G^{\circ\prime} + RT\ln\left[\frac{[ADP][Pi]}{[ATP]}\right]$$

$$= -30.5 kJ/mole + (8.3x10^{-3} kJ/mole/°K)(310°K)\ln\left[\frac{(0.8x10^{-3} M)(4.0x10^{-3} M)}{3.0x10^{-3} M}\right]$$

$$= -30.5 kJ/mole - 17.6 kJ/mole = -48.1 kJ/mole$$

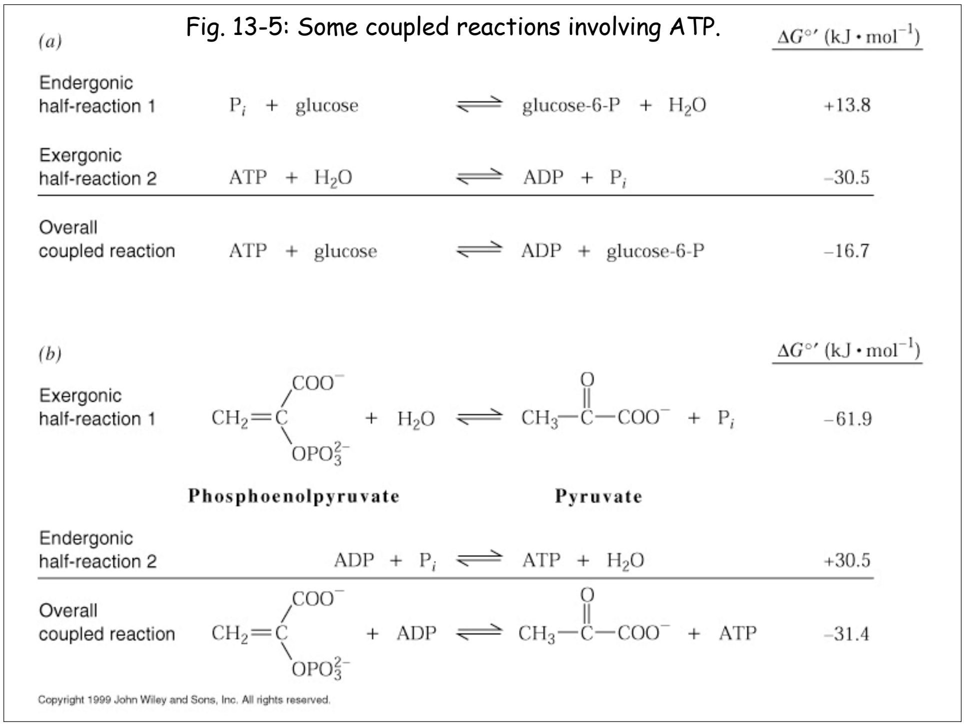


Fig. 13-5: Some coupled reactions involving ATP.

(a)

	Reaction	$\Delta G^{\circ\prime}$ (kJ • mol^{-1})
Endergonic half-reaction 1	$P_i + \text{glucose} \rightleftharpoons \text{glucose-6-P} + H_2O$	+13.8
Exergonic half-reaction 2	$ATP + H_2O \rightleftharpoons ADP + P_i$	–30.5
Overall coupled reaction	$ATP + \text{glucose} \rightleftharpoons ADP + \text{glucose-6-P}$	–16.7

(b)

	Reaction	$\Delta G^{\circ\prime}$ (kJ • mol^{-1})
Exergonic half-reaction 1	$CH_2{=}C(COO^-)(OPO_3^{2-}) + H_2O \rightleftharpoons CH_3{-}C(=O){-}COO^- + P_i$ Phosphoenolpyruvate → Pyruvate	–61.9
Endergonic half-reaction 2	$ADP + P_i \rightleftharpoons ATP + H_2O$	+30.5
Overall coupled reaction	$CH_2{=}C(COO^-)(OPO_3^{2-}) + ADP \rightleftharpoons CH_3{-}C(=O){-}COO^- + ATP$	–31.4

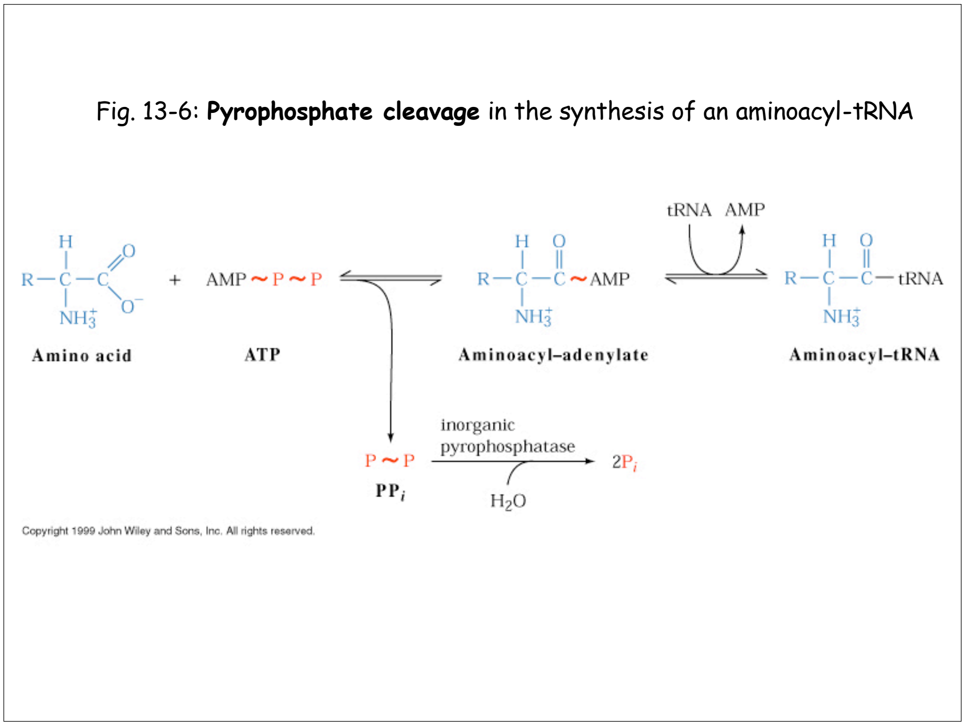
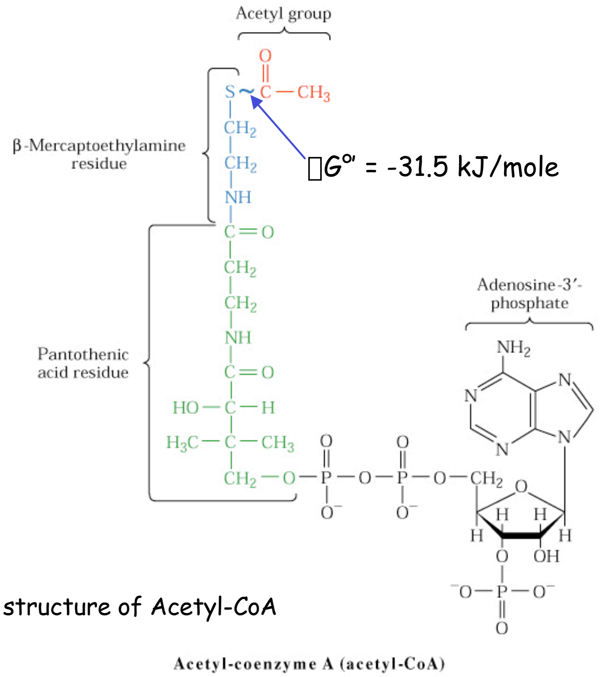


Fig. 13-6: **Pyrophosphate cleavage** in the synthesis of an aminoacyl-tRNA



$\Delta G^{\circ\prime}$ = -31.5 kJ/mole

Fig. 13-9: The chemical structure of Acetyl-CoA

Acetyl-coenzyme A (acetyl-CoA)

Fig. 13-10: Reduction of NAD$^+$ to NADH

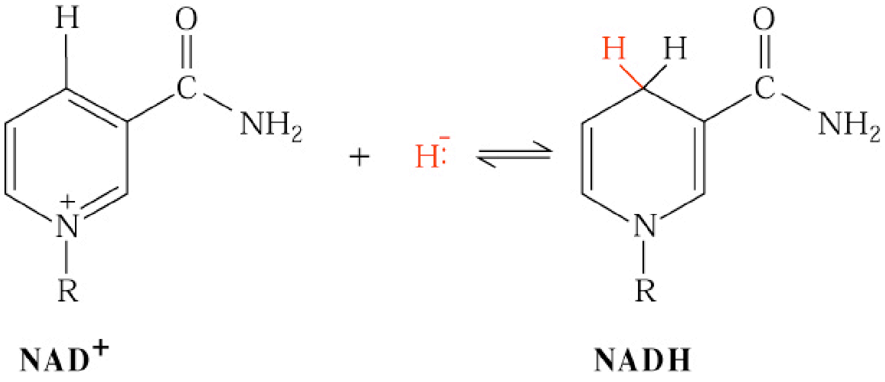
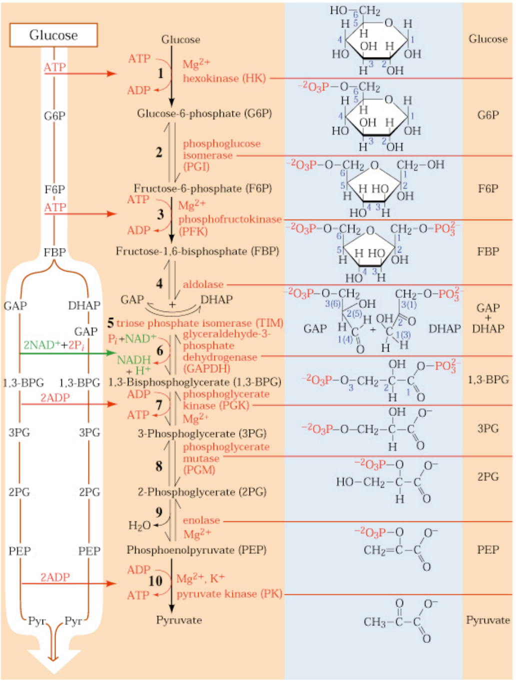
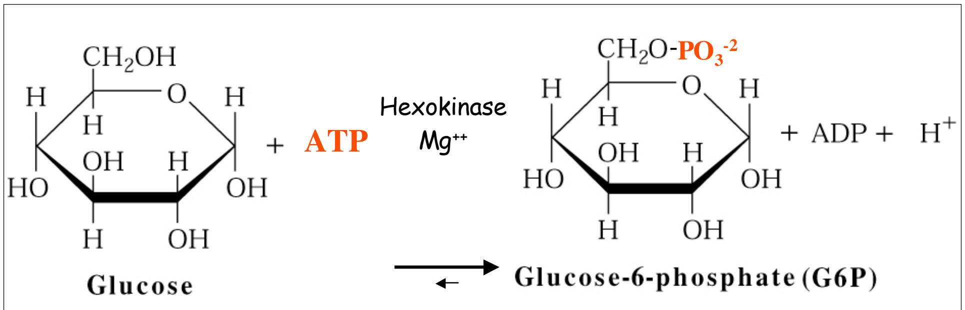


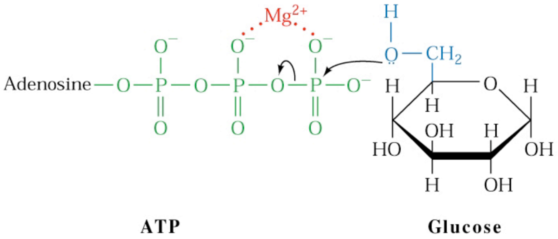
Figure 13-10. Reduction of NAD$^+$ to NADH.

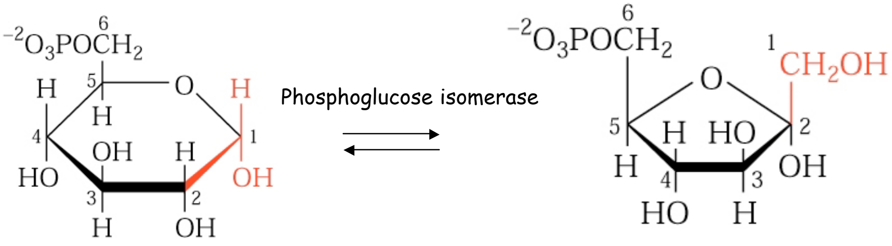
Fig. 14-1: Glycolysis





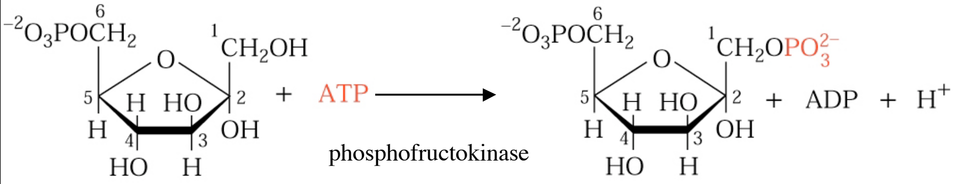
1 ATP used to phosphorylate C6 on Glucose





Glucose-6-phosphate (G6P)

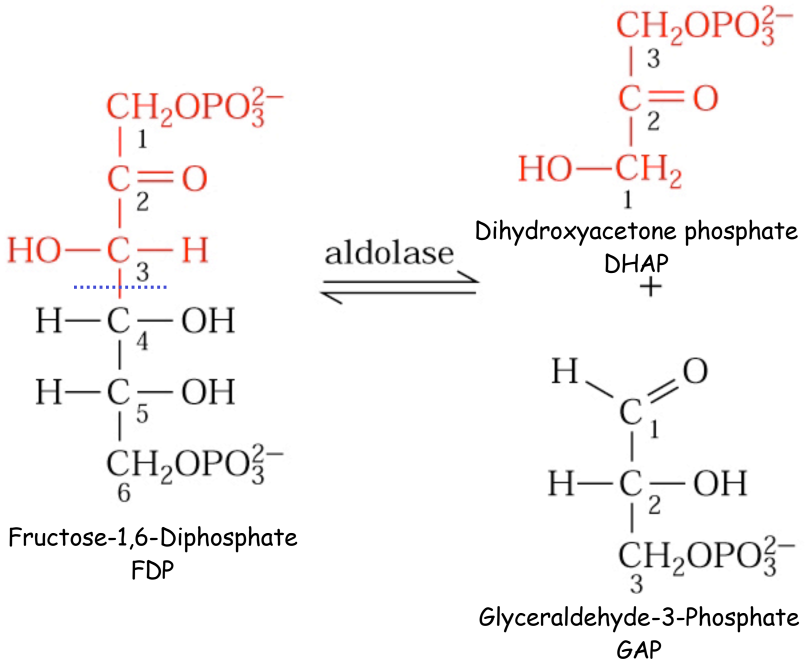
Fructose-6-phosphate (F6P)



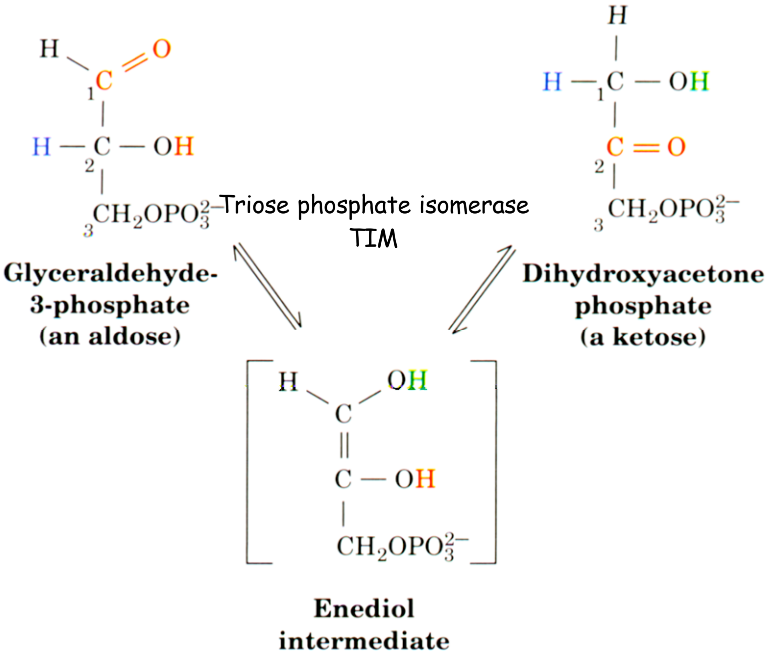
Fructose-6-phosphate (F6P)

Fructose-1,6-bisphosphate (FBP)

1 ATP used to phosphorylate C1 on Fructose-6-phosphate
Total of 2 ATP used so far



Fructose-1,6-Diphosphate
FDP
aldolase
Dihydroxyacetone phosphate
DHAP
+
Glyceraldehyde-3-Phosphate
GAP

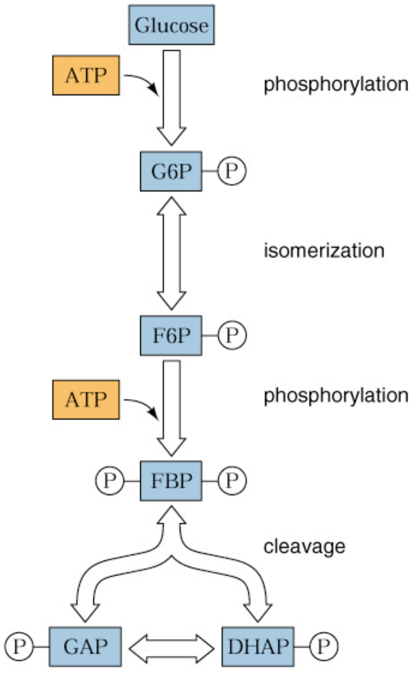


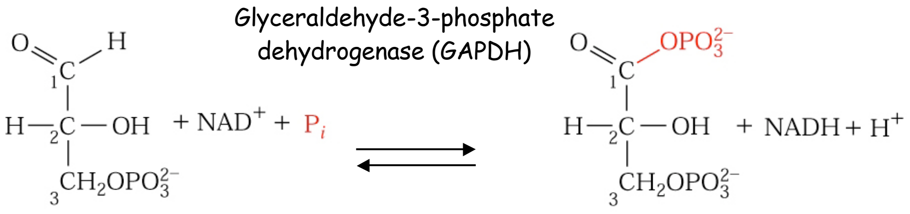
Triose phosphate isomerase
TIM
Glyceraldehyde-3-phosphate (an aldose)
Dihydroxyacetone phosphate (a ketose)
Enediol intermediate

Fig. 14-7:
Schematic view of the first stage of glycolysis

2 ATP consumed

2 molecules of glyceraldehyde-3P produced

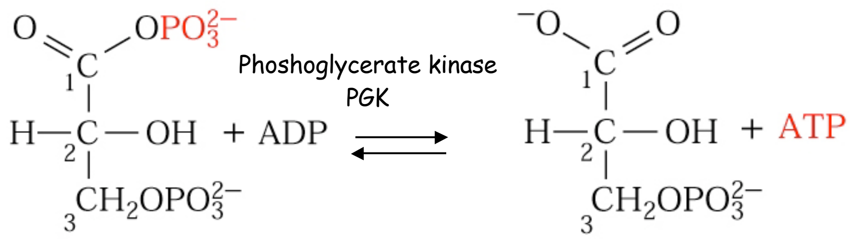




Glyceraldehyde-3-phosphate (GAP)

1,3-Bisphosphoglycerate (1,3-BPG)

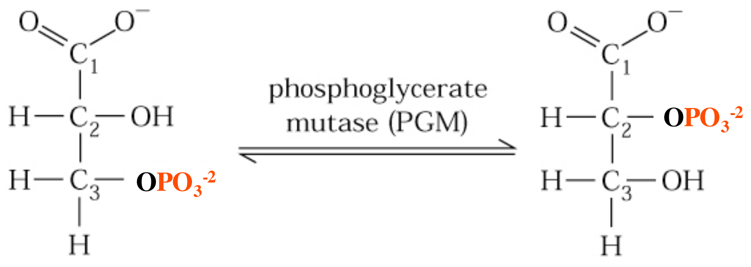
2 NADH produced, 1 from each of the Glyceraldehye-3-P produced in Stage 1



1,3-Bisphosphoglycerate (1,3-BPG)

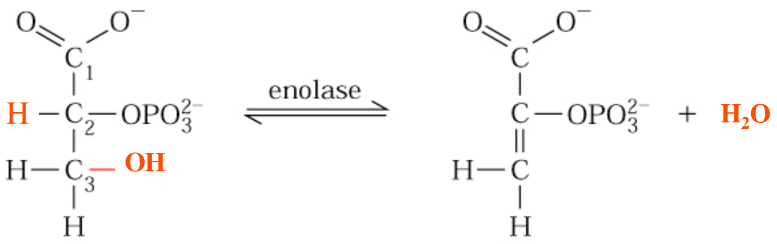
3-Phosphoglycerate (3PG)

A total of 2 ATP from the 2 1,3-BPG molecules produced from each glucose entering glycolysis



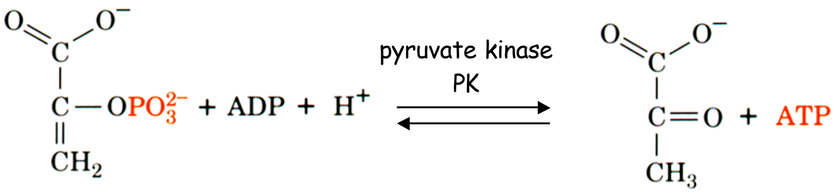
3-Phosphoglycerate (3PG)

2-Phosphoglycerate (2PG)



2-Phosphoglycerate (2PG)

Phosphoenolpyruvate (PEP)



Phosphoenolpyruvate (PEP)

Pyruvate

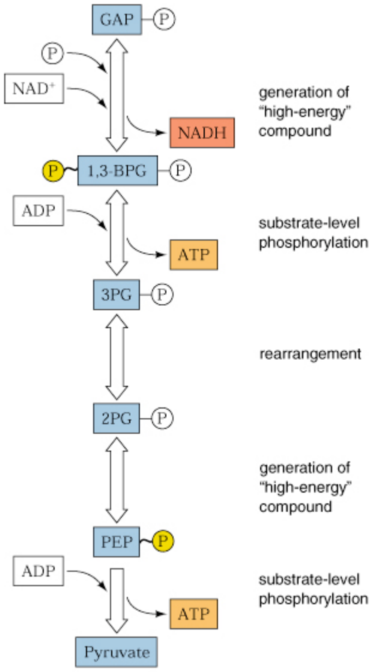
2 more ATP produced, 1 from each of the PEP molecules produced from each Glucose entering glycolysis

Fig. 14-15:

Schematic view of the second stage of glycolysis

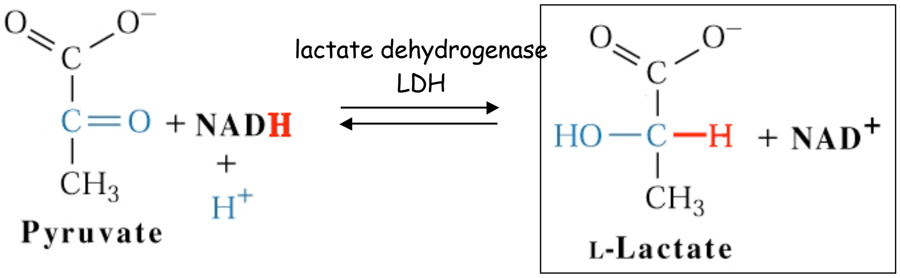
2 ATP produced for each pyruvate produced for a total of 4 ATP from each glucose that enters glycolysis

2 NADH also produced 1 for each pyruvate



What happens to Pyruvate? This depends…

Lactic Fermentation



Alcoholic Fermentation

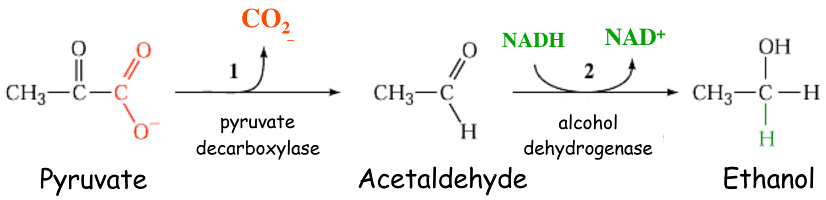
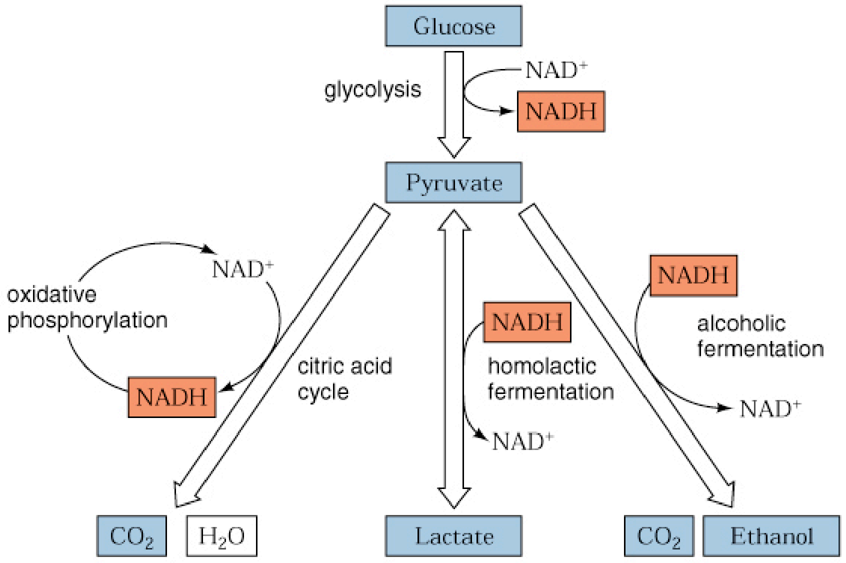


Fig. 14-16:Metabolic fate of pyruvate



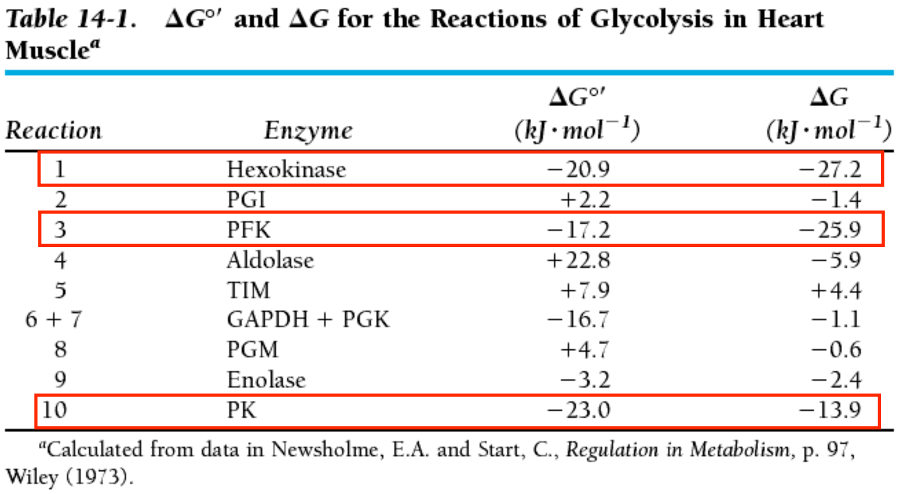
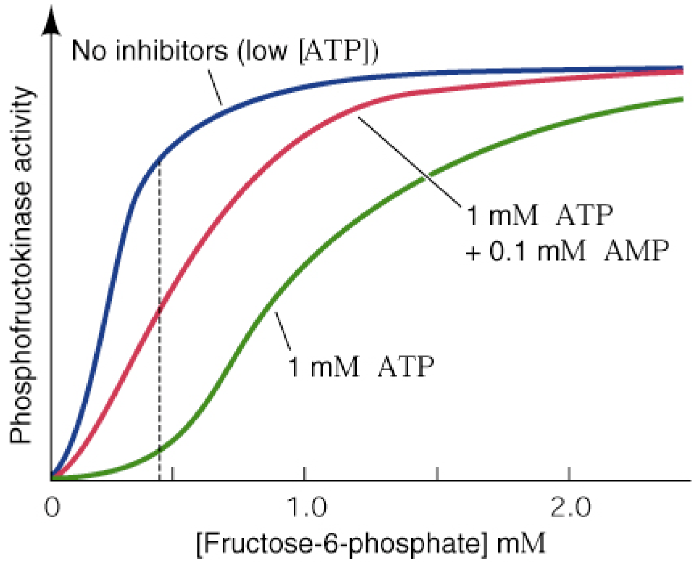


Table 14-1. **$\Delta G^{\circ\prime}$ and ΔG for the Reactions of Glycolysis in Heart Muscle**[a]

Reaction	*Enzyme*	$\Delta G^{\circ\prime}$ (kJ·mol^{-1})	ΔG (kJ·mol^{-1})
1	Hexokinase	−20.9	−27.2
2	PGI	+2.2	−1.4
3	PFK	−17.2	−25.9
4	Aldolase	+22.8	−5.9
5	TIM	+7.9	+4.4
6 + 7	GAPDH + PGK	−16.7	−1.1
8	PGM	+4.7	−0.6
9	Enolase	−3.2	−2.4
10	PK	−23.0	−13.9

[a] Calculated from data in Newsholme, E.A. and Start, C., *Regulation in Metabolism*, p. 97, Wiley (1973).



After data from Mansour, T.E. and Ahlfors, C.E., *J. Biol. Chem.* 243, 2523-2533 (1968).

Fig. 14-22: Regulation of PFK activity

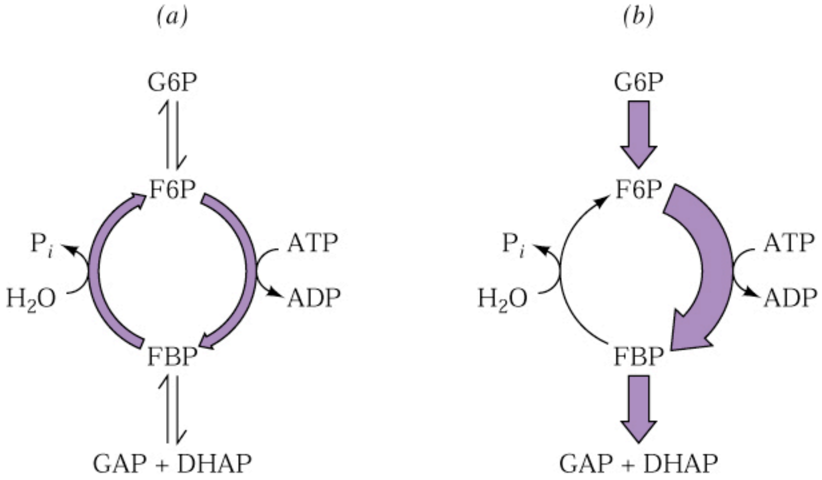


Fig. 14-24: Substrate cycling in the regulation of PFK