

# TEMA 24

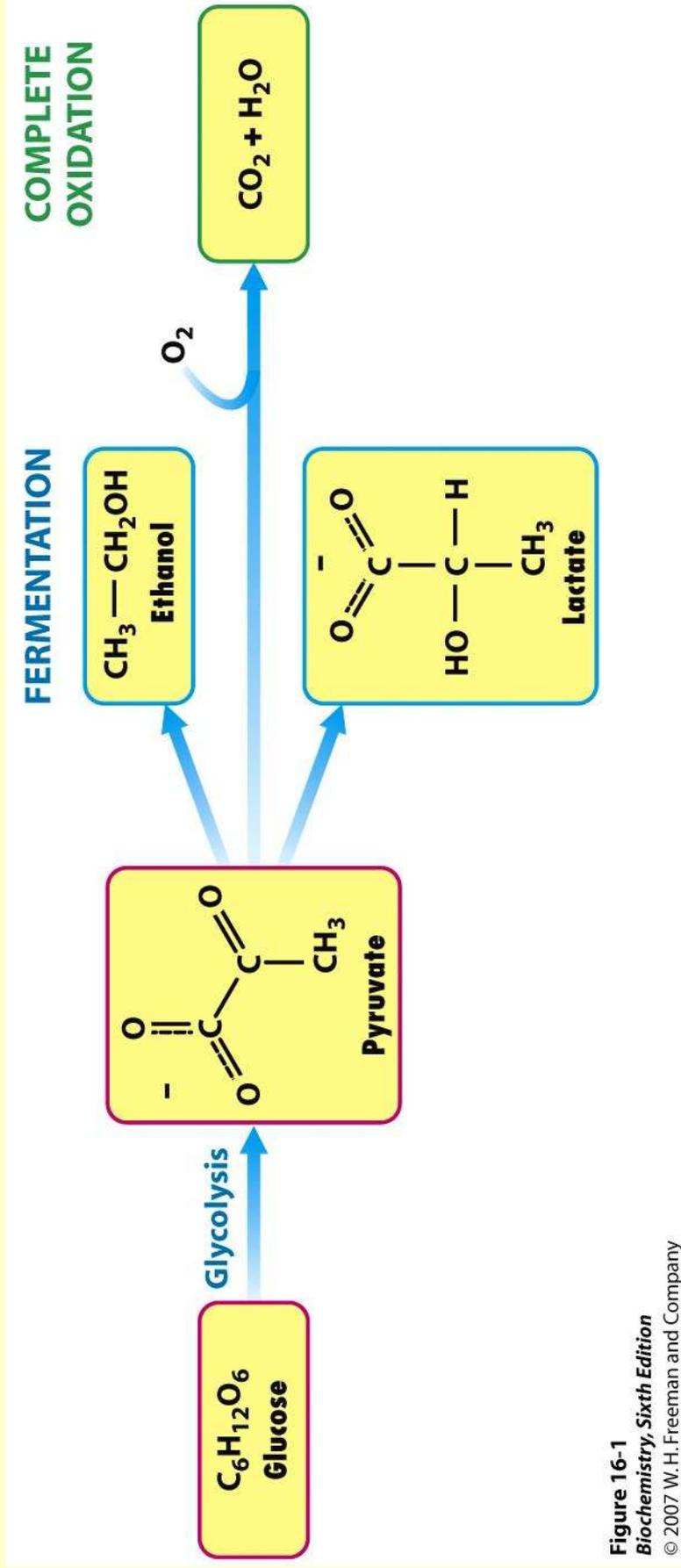
**Glucolisis. Importancia, reacciones, rendimiento energético y regulación. Papel de la fructosa 2,6-bisfosfato. Lanzaderas. Entrada de otros azúcares en la ruta glucolítica.**

# TEMA 24

**Las Figuras recogidas en este tema proceden de los siguientes textos:**

**- Berg • Tymoczko • Stryer. Biochemistry. Sixth Edition. 2007. W. H. Freeman and Company.**

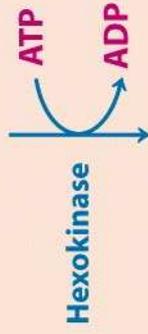
**- Donald Voet • Judith G. Voet • Charlotte W. Pratt. Fundamentals of Biochemistry. Second Edition. 2006 by John Wiley & Sons, Inc.**



**Figure 16-1**  
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**Stage 1**

**Glucose**



**Glucose 6-phosphate**



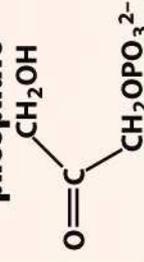
**Fructose 6-phosphate**



**Fructose 1,6-bisphosphate**

**Stage 2**

**Dihydroxyacetone phosphate**



**Glyceraldehyde 3-phosphate**

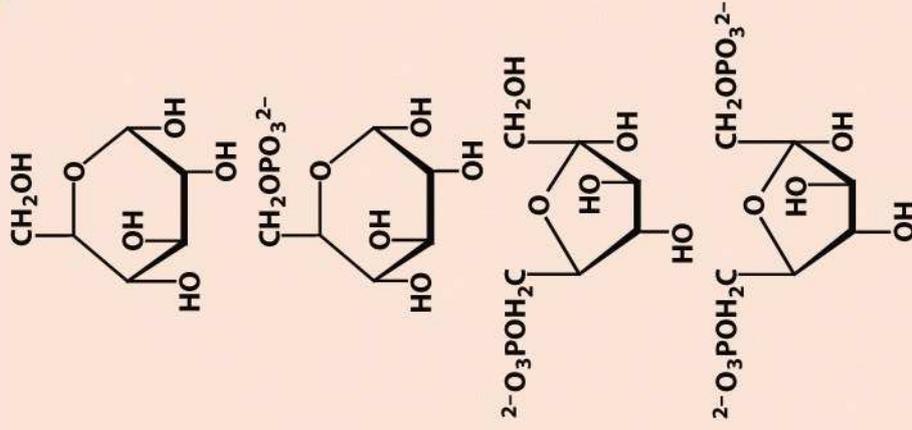
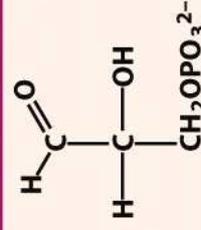
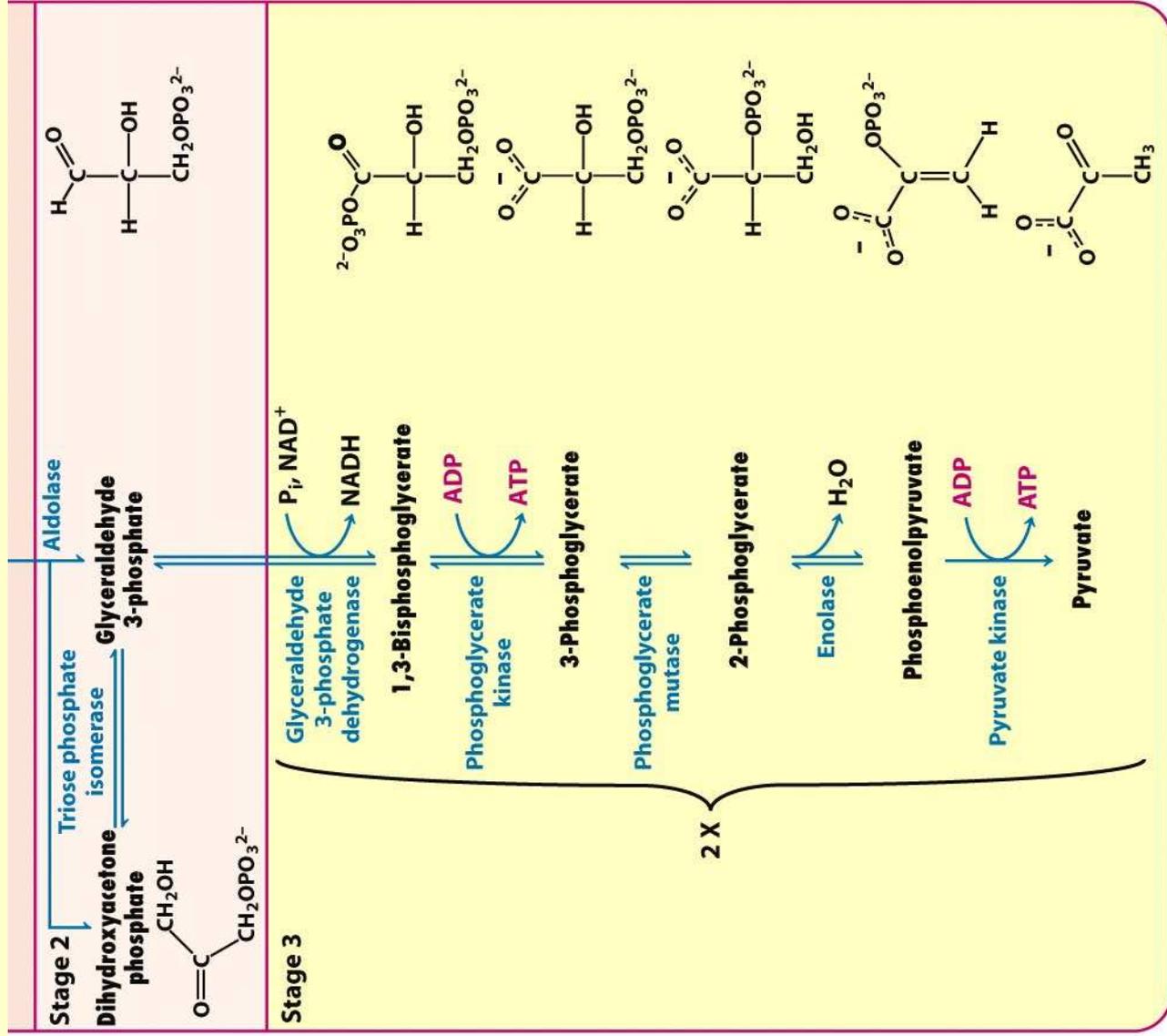
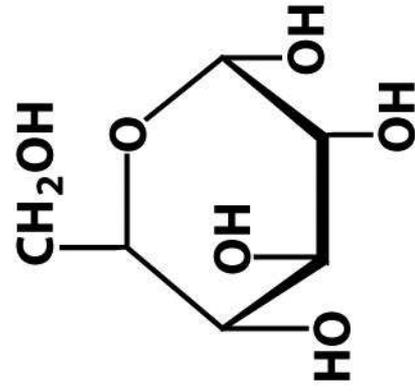


Figure 16-2 part 1  
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**Figure 16-2 part 2**  
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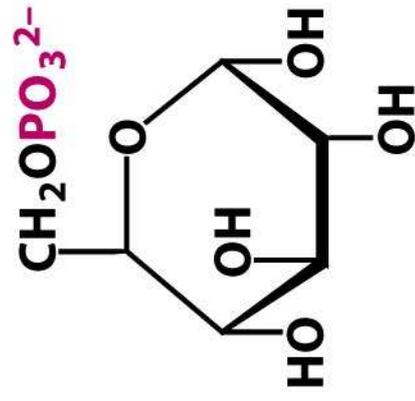


**Glucose**

Hexokinase



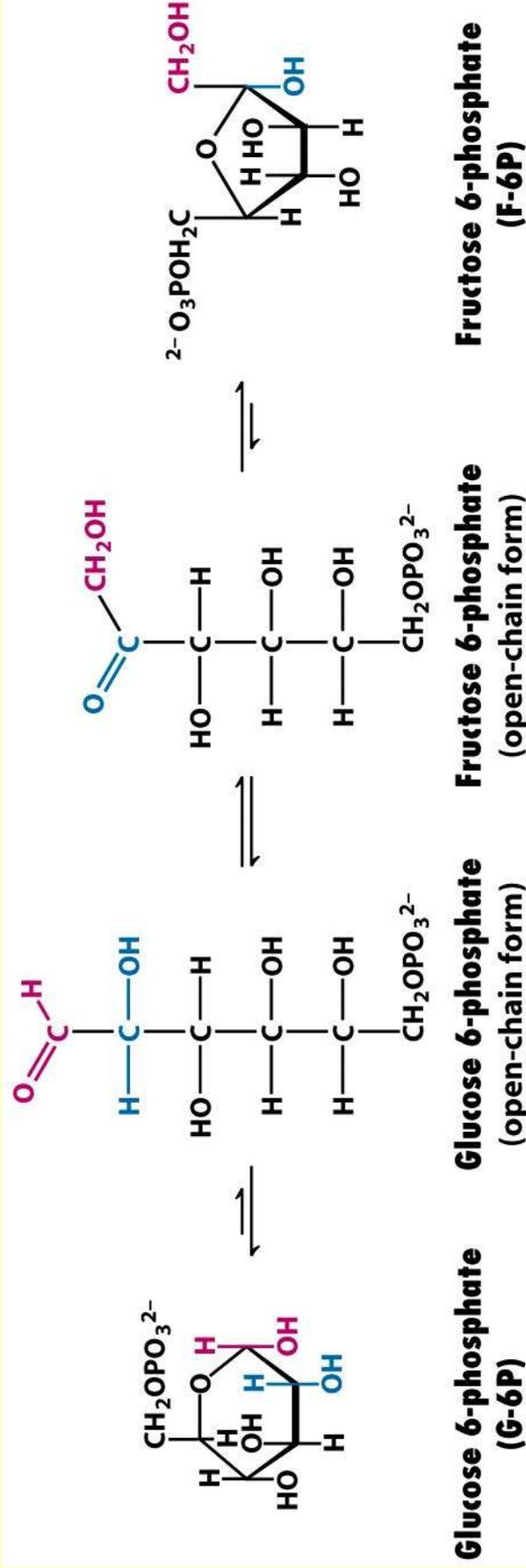
+ ATP



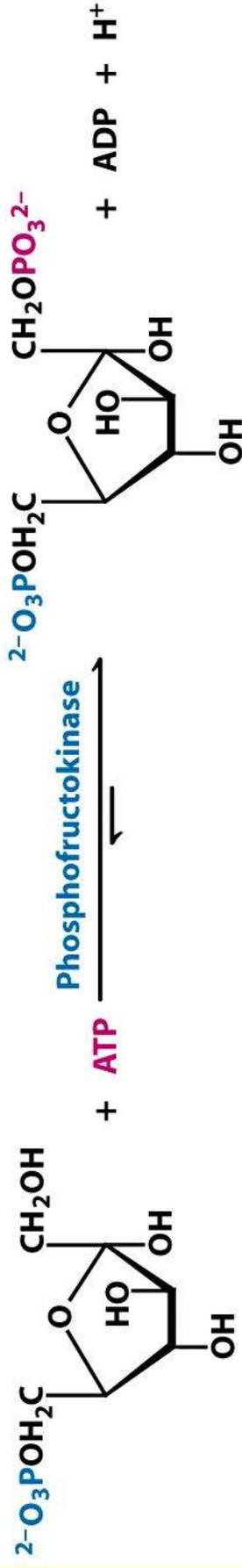
**Glucose 6-phosphate  
(G-6P)**

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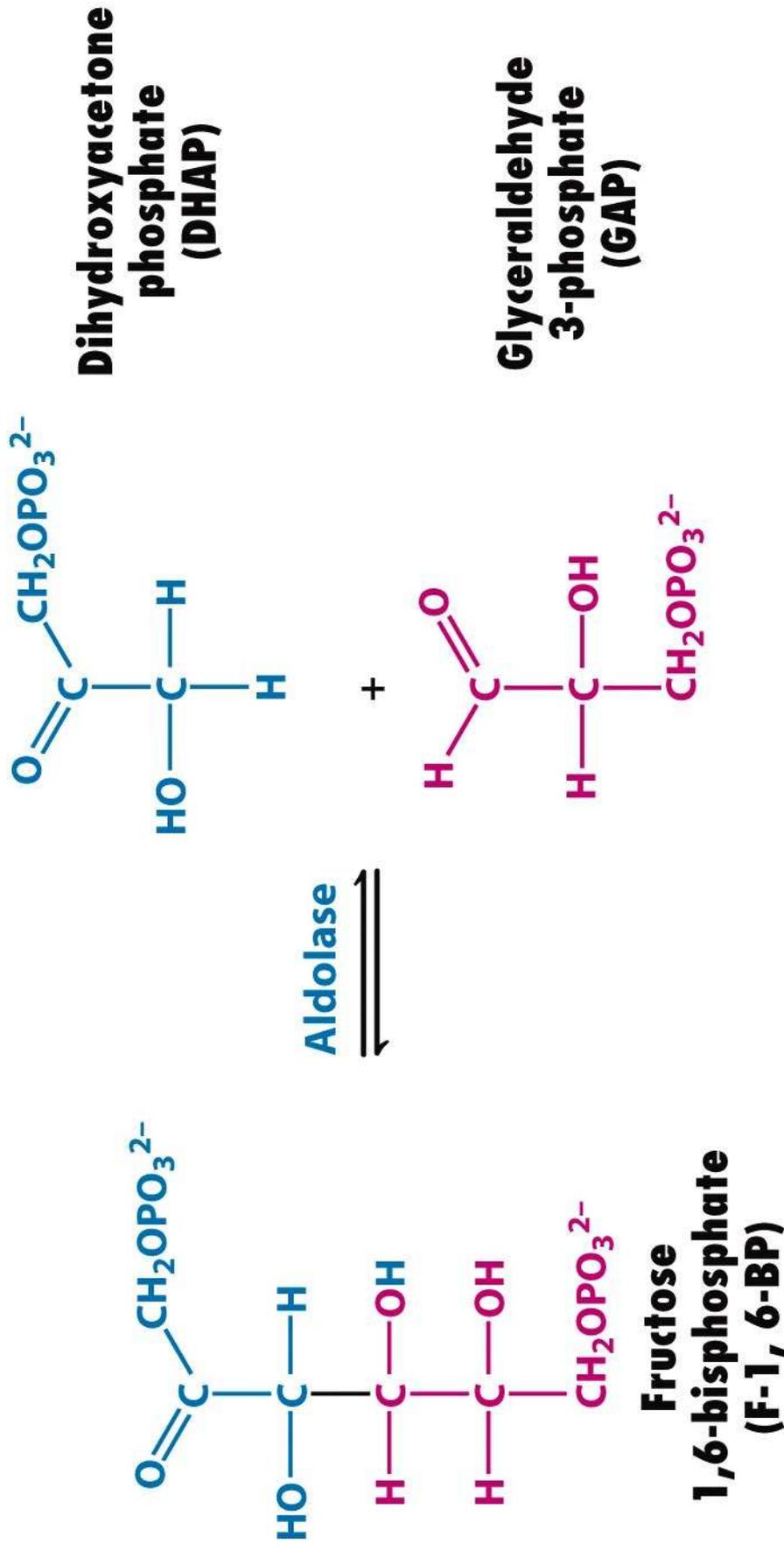


**Fructose 6-phosphate  
(F-6P)**

**Fructose 1,6-bisphosphate  
(F-1, 6-BP)**

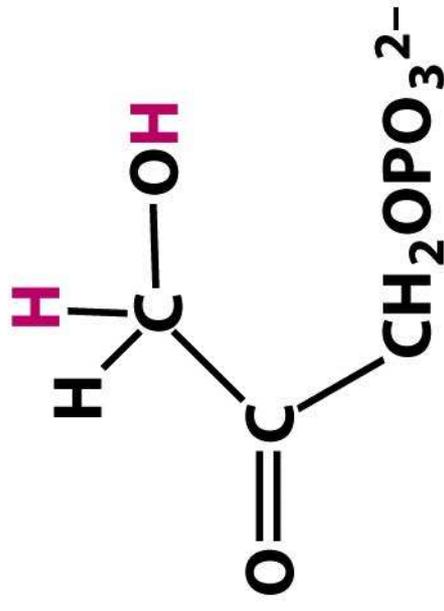
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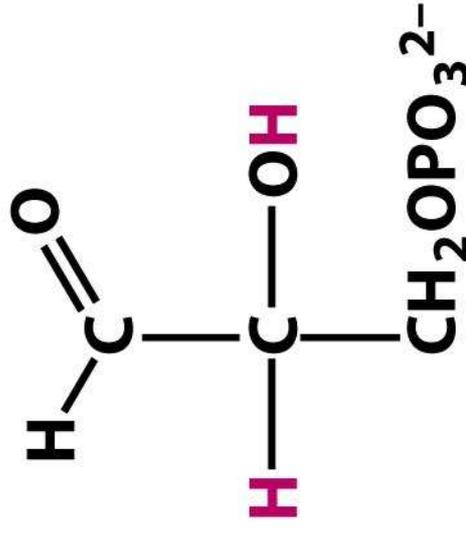
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**Dihydroxyacetone  
phosphate**

Triose phosphate  
isomerase



**Glyceraldehyde  
3-phosphate**

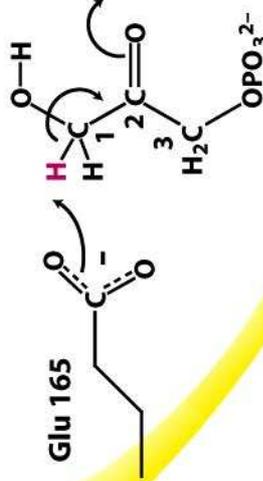
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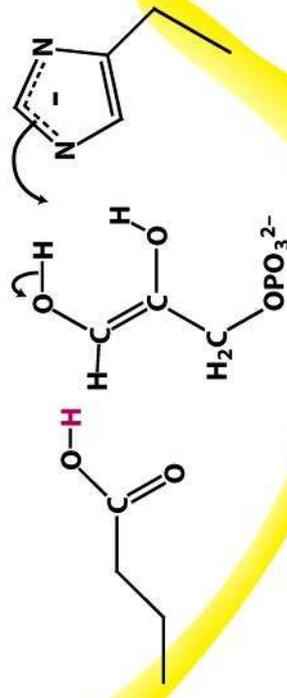
### Dihydroxyacetone phosphate

His 95



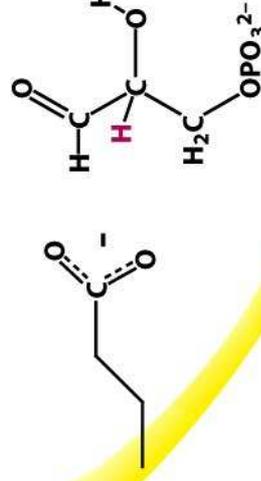
①

### Enediol intermediate



②

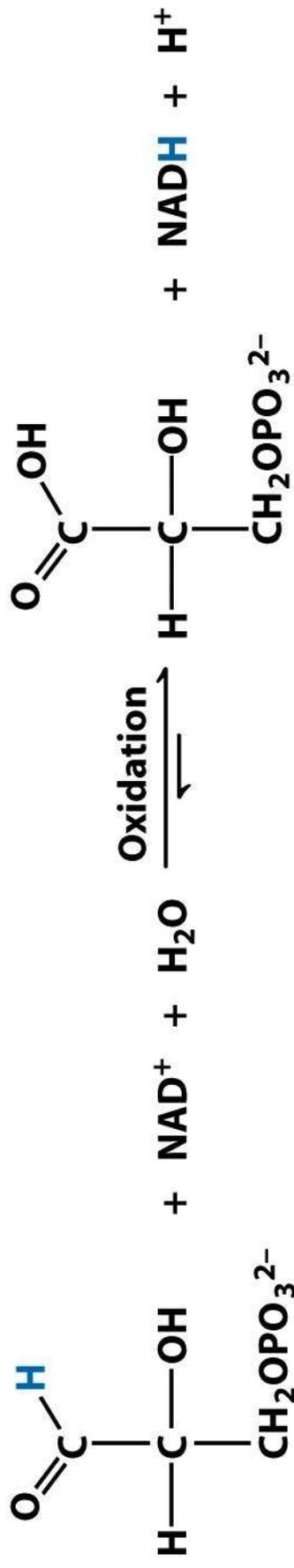
### Glyceraldehyde 3-phosphate



③

Figure 16-5  
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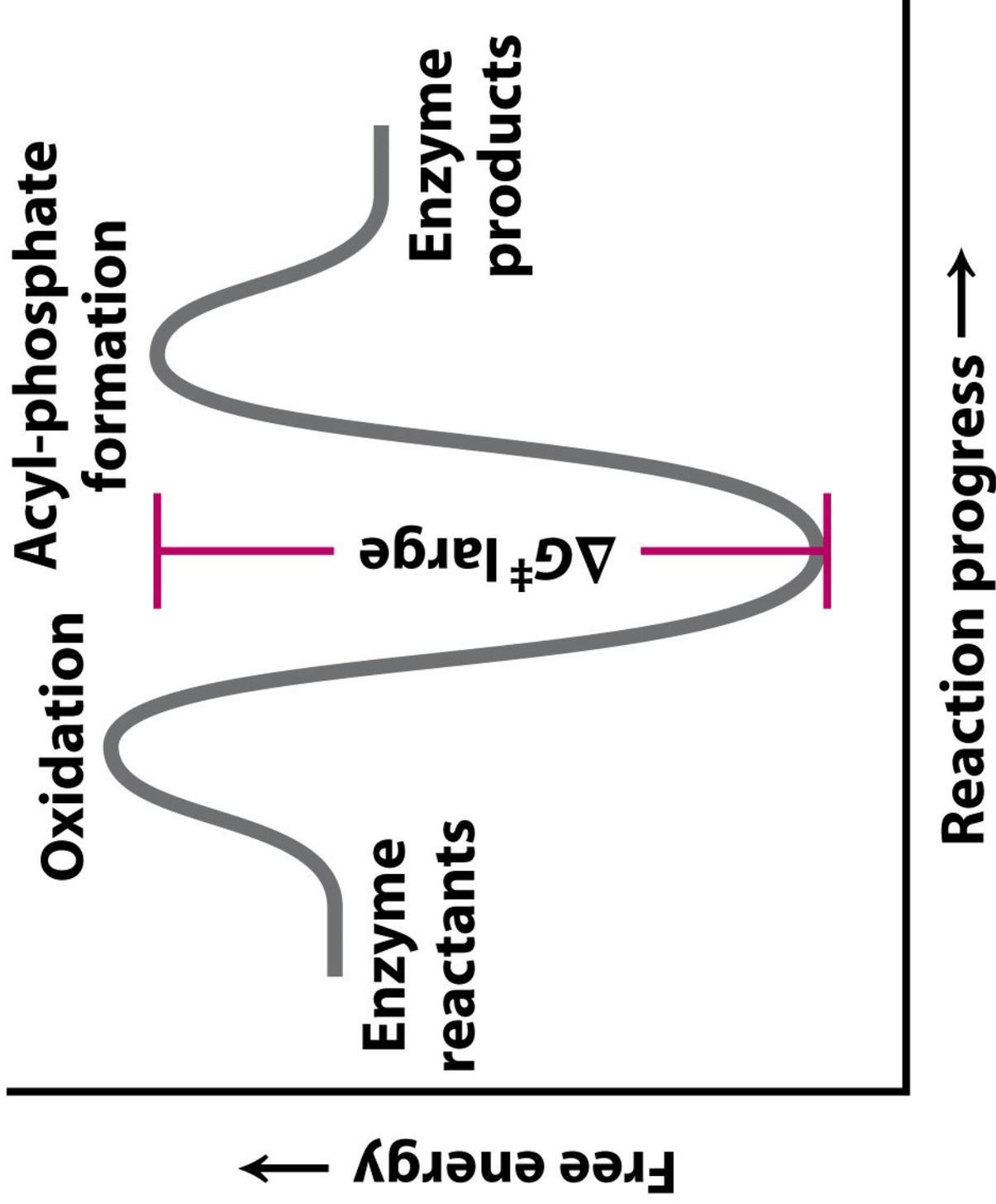


Figure 16-7a  
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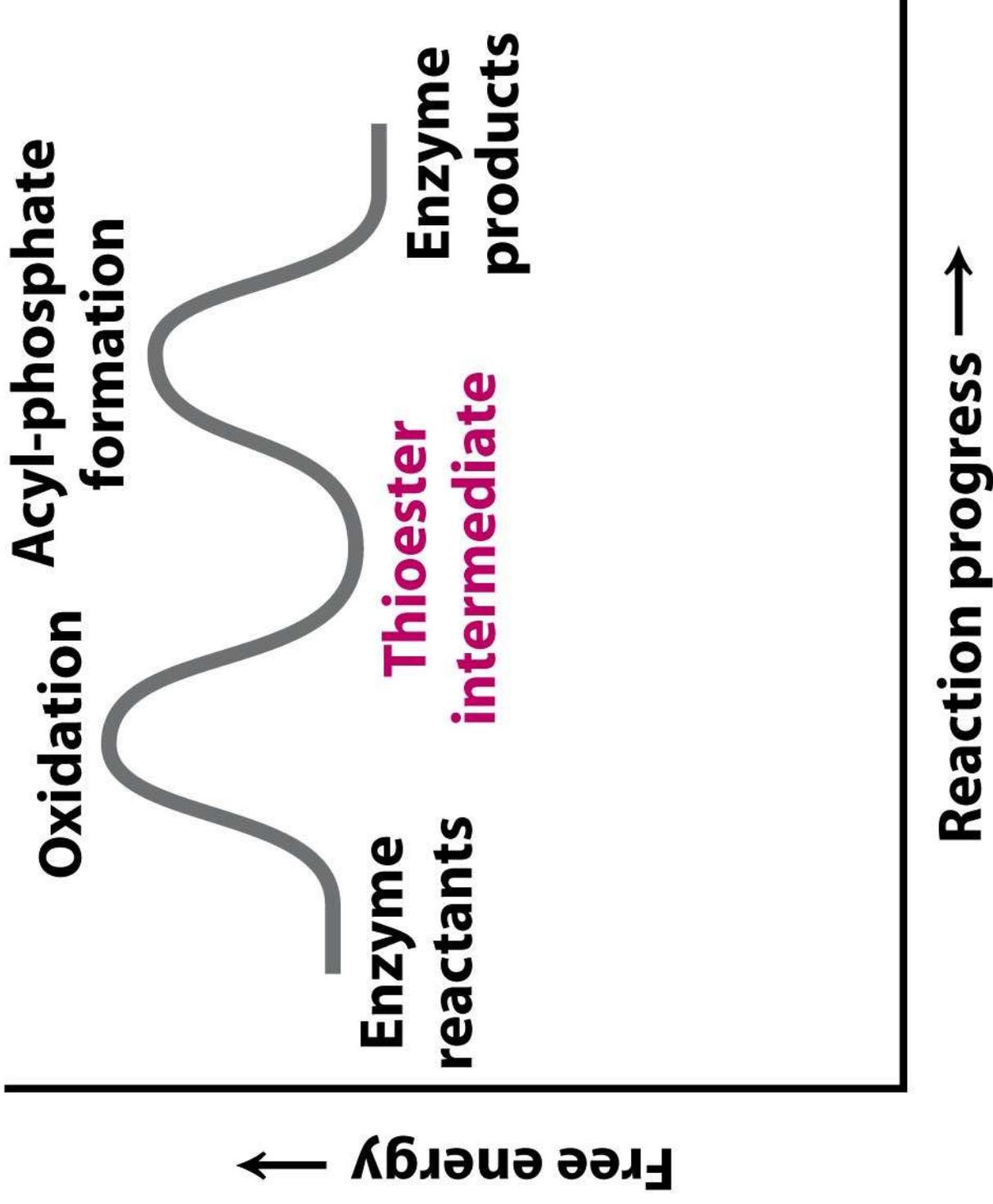
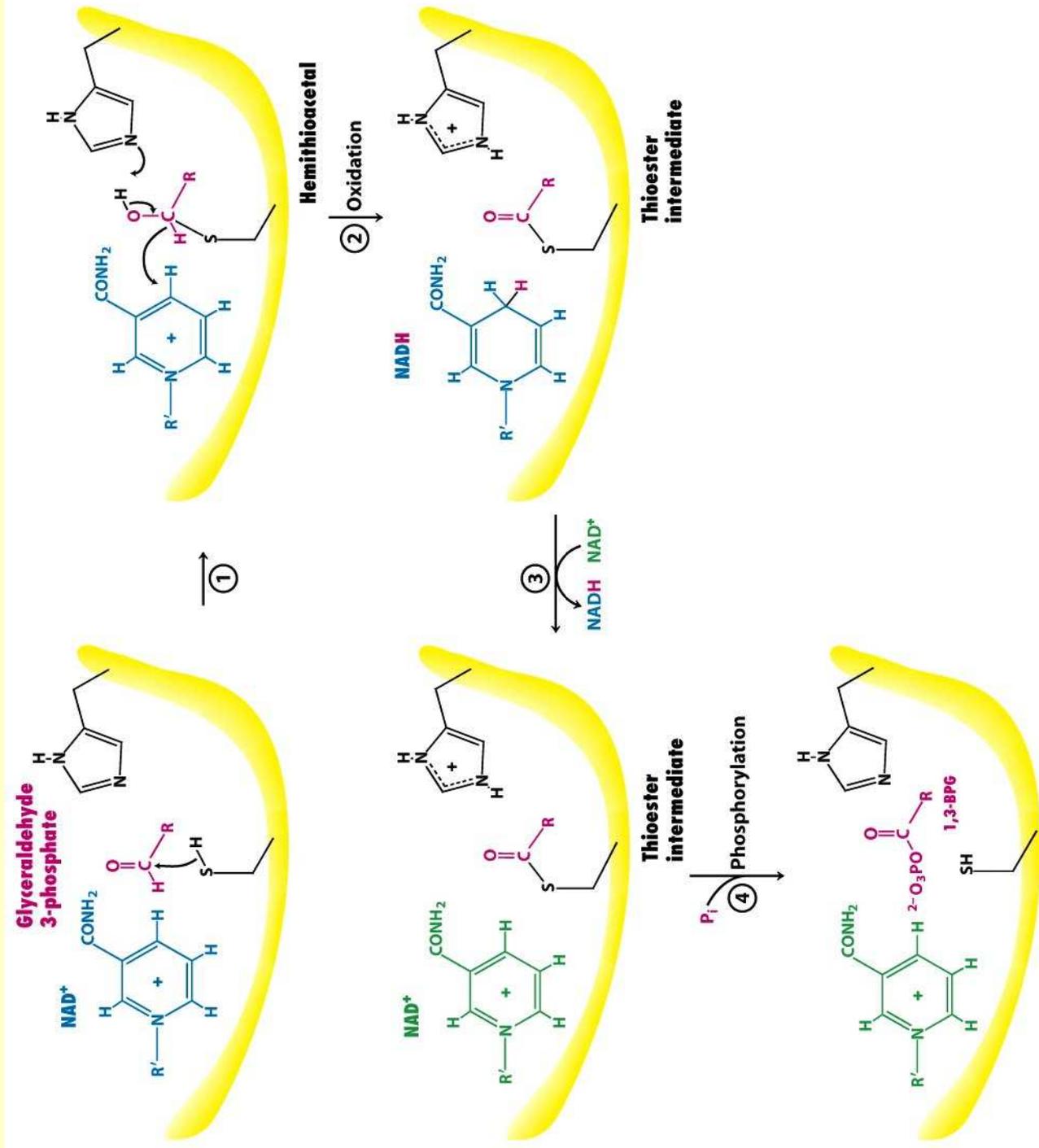
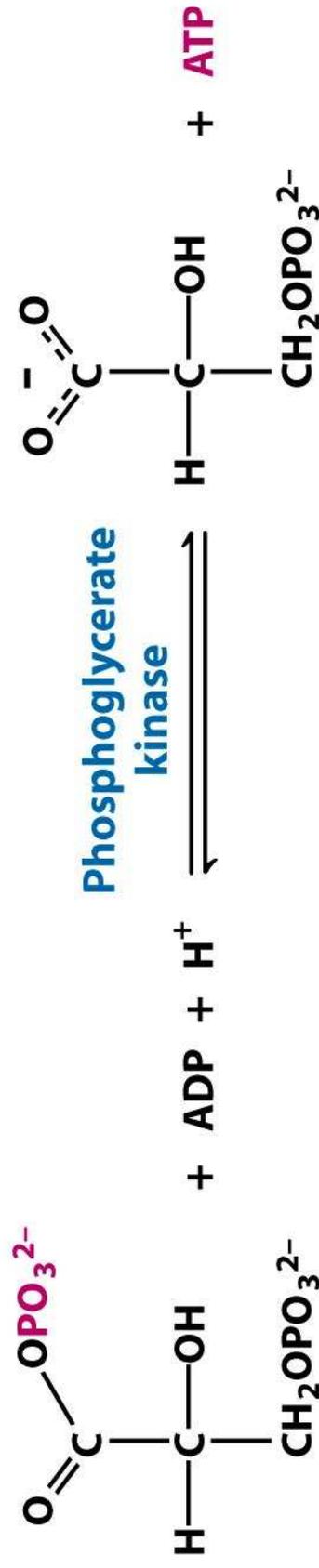


Figure 16-7b  
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**Figure 16-8**  
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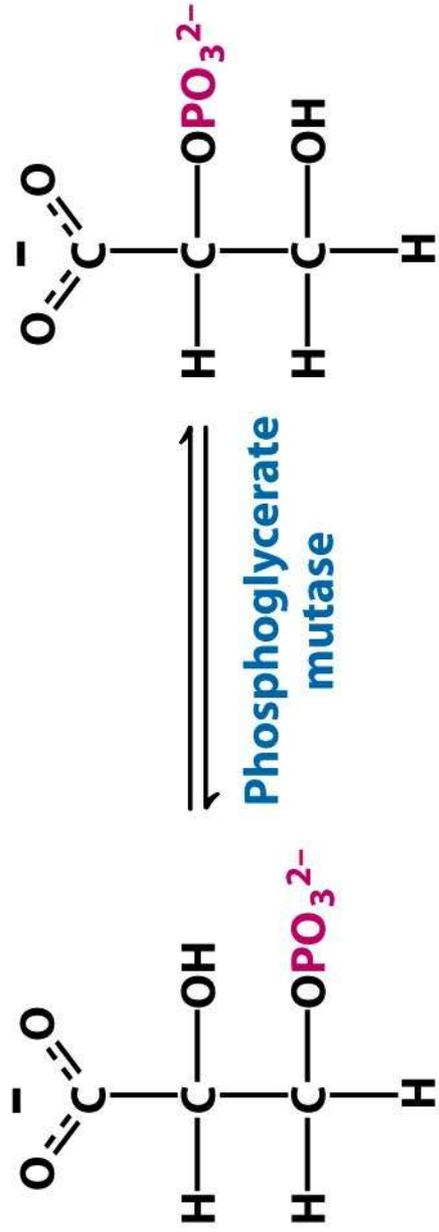
**1,3-Bisphosphoglycerate**

**3-Phosphoglycerate**

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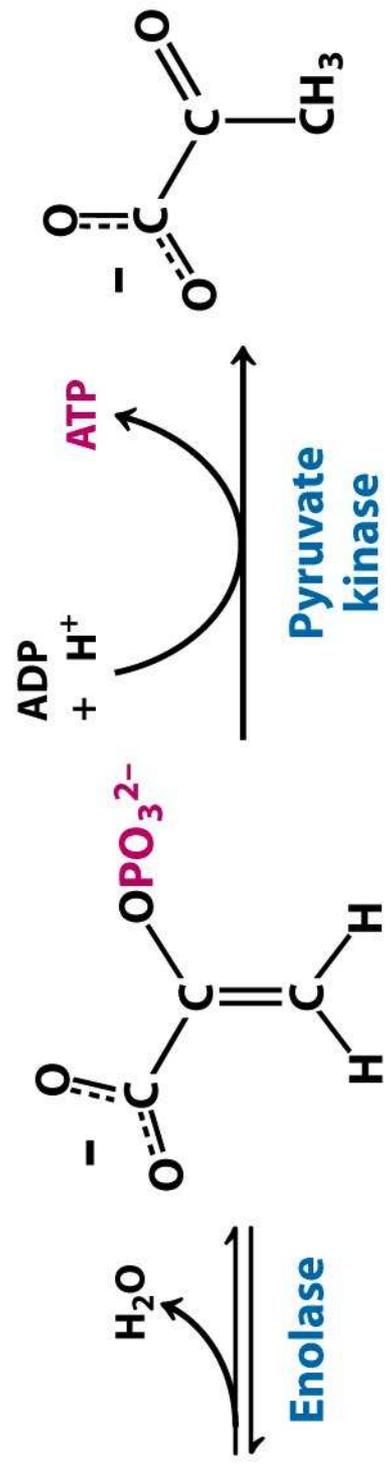
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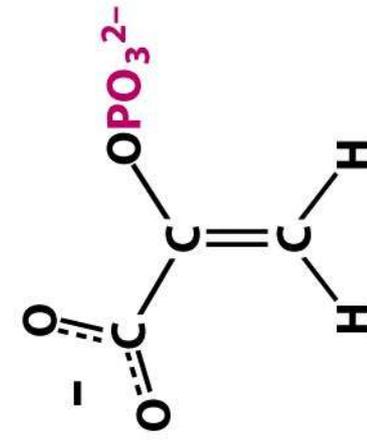
**3-Phosphoglycerate**

**2-Phosphoglycerate**



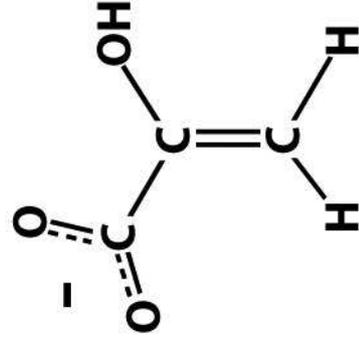
**Phosphoenolpyruvate**

**Pyruvate**

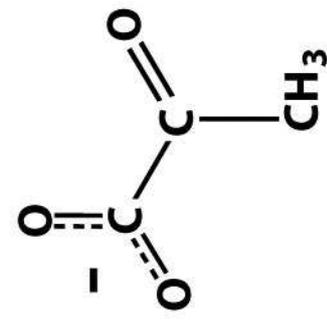


### Phosphoenolpyruvate

ADP + H<sup>+</sup> → ATP



### Pyruvate (enol form)



### Pyruvate

**TABLE 16.1 Reactions of glycolysis**

<b>Step</b>	<b>Reaction</b>
<b>1</b>	<b>Glucose + ATP <math>\rightarrow</math> glucose 6-phosphate + ADP + H<sup>+</sup></b>
<b>2</b>	<b>Glucose 6-phosphate <math>\rightleftharpoons</math> fructose 6-phosphate</b>
<b>3</b>	<b>Fructose 6-phosphate + ATP <math>\rightarrow</math> fructose 1,6-bisphosphate + ADP + H<sup>+</sup></b>
<b>4</b>	<b>Fructose 1,6-bisphosphate <math>\rightleftharpoons</math> dihydroxyacetone phosphate + glyceraldehyde 3-phosphate</b>
<b>5</b>	<b>Dihydroxyacetone phosphate <math>\rightleftharpoons</math> glyceraldehyde 3-phosphate</b>
<b>6</b>	<b>Glyceraldehyde 3-phosphate + P<sub>i</sub> + NAD<sup>+</sup> <math>\rightleftharpoons</math> 1,3-bisphosphoglycerate + NADH + H<sup>+</sup></b>
<b>7</b>	<b>1,3-Bisphosphoglycerate + ADP <math>\rightleftharpoons</math> 3-phosphoglycerate + ATP</b>
<b>8</b>	<b>3-Phosphoglycerate <math>\rightleftharpoons</math> 2-phosphoglycerate</b>
<b>9</b>	<b>2-Phosphoglycerate <math>\rightleftharpoons</math> phosphoenolpyruvate + H<sub>2</sub>O</b>
<b>10</b>	<b>Phosphoenolpyruvate + ADP + H<sup>+</sup> <math>\rightarrow</math> pyruvate + ATP</b>

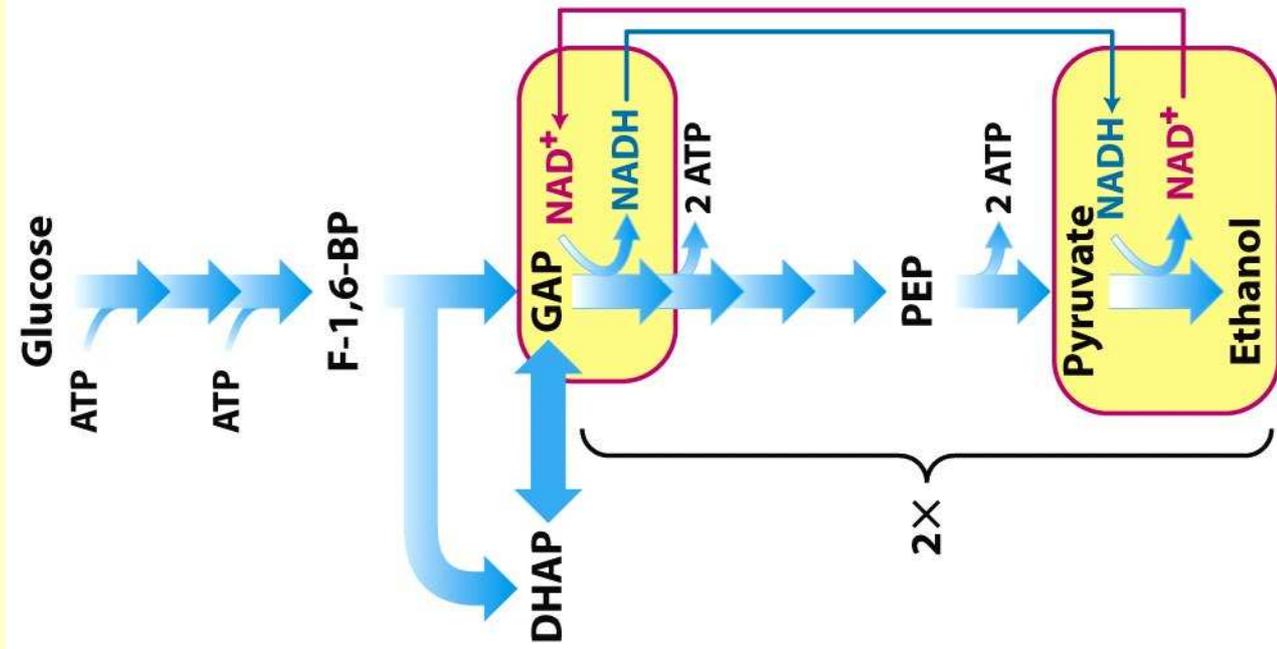
**Note:**  $\Delta G$ , the actual free-energy change, has been calculated from  $\Delta G^\circ$  and known concentrations of reactants under typical physiological conditions. Glycolysis can proceed only if the  $\Delta G$  values of all reactions are negative. The small positive  $\Delta G$  values of three of the above reactions indicate that the concentrations of metabolites in vivo in cells undergoing glycolysis are not precisely known.

<b>Enzyme</b>	<b>Reaction type</b>	<b><math>\Delta G^\circ</math> in kJ mol<sup>-1</sup> (kcal mol<sup>-1</sup>)</b>	<b><math>\Delta G</math> in kJ mol<sup>-1</sup> (kcal mol<sup>-1</sup>)</b>
<b>Hexokinase</b>	<b>Phosphoryl transfer</b>	<b>-16.7 (-4.0)</b>	<b>-33.5 (-8.0)</b>
<b>Phosphoglucose isomerase</b>	<b>Isomerization</b>	<b>+1.7 (+0.4)</b>	<b>-2.5 (-0.6)</b>
<b>Phosphofructokinase</b>	<b>Phosphoryl transfer</b>	<b>-14.2 (-3.4)</b>	<b>-22.2 (-5.3)</b>
<b>Aldolase</b>	<b>Aldol cleavage</b>	<b>+23.8 (+5.7)</b>	<b>-1.3 (-0.3)</b>
<b>Triose phosphate isomerase</b>	<b>Isomerization</b>	<b>+7.5 (+1.8)</b>	<b>+2.5 (+0.6)</b>
<b>Glyceraldehyde 3-phosphate dehydrogenase</b>	<b>Phosphorylation coupled to oxidation</b>	<b>+6.3 (+1.5)</b>	<b>-1.7 (-0.4)</b>
<b>Phosphoglycerate kinase</b>	<b>Phosphoryl transfer</b>	<b>-18.8 (-4.5)</b>	<b>+1.3 (+0.3)</b>
<b>Phosphoglycerate mutase</b>	<b>Phosphoryl shift</b>	<b>+4.6 (+1.1)</b>	<b>+0.8 (+0.2)</b>
<b>Enolase</b>	<b>Dehydration</b>	<b>+1.7 (+0.4)</b>	<b>-3.3 (-0.8)</b>
<b>Pyruvate kinase</b>	<b>Phosphoryl transfer</b>	<b>-31.4 (-7.5)</b>	<b>-16.7 (-4.0)</b>

**Table 16-1 part 2**  
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**Reacción global de la transformación de glucosa en piruvato:**





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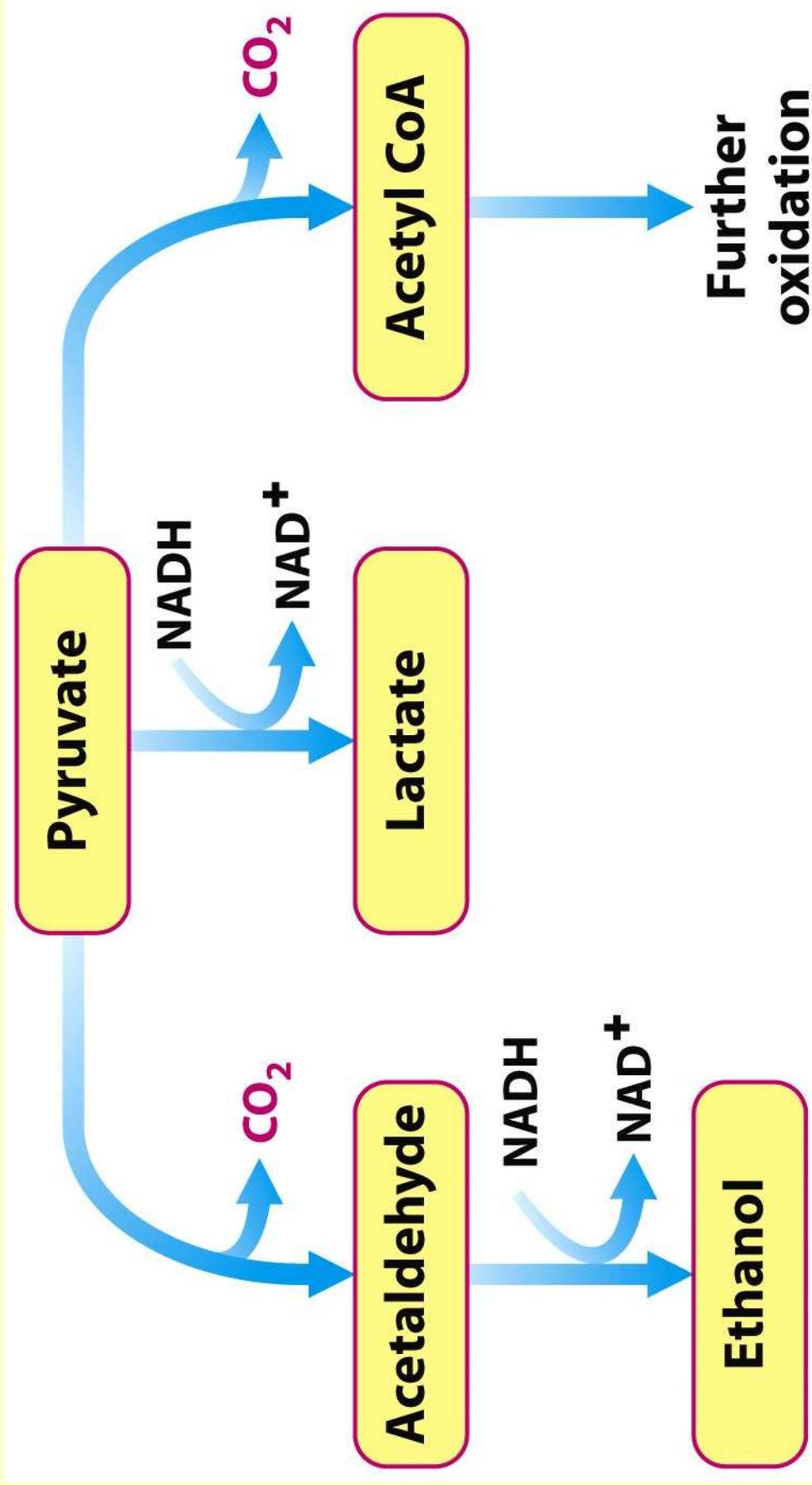
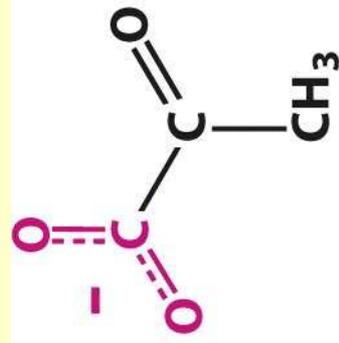
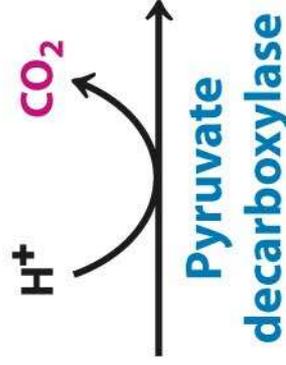


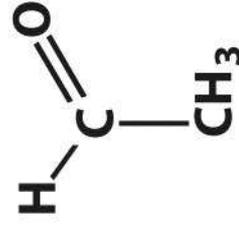
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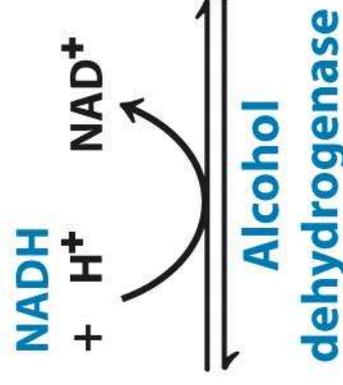
## Pyruvate



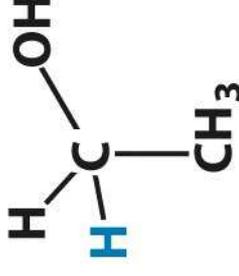
Pyruvate  
decarboxylase



## Acetaldehyde



Alcohol  
dehydrogenase

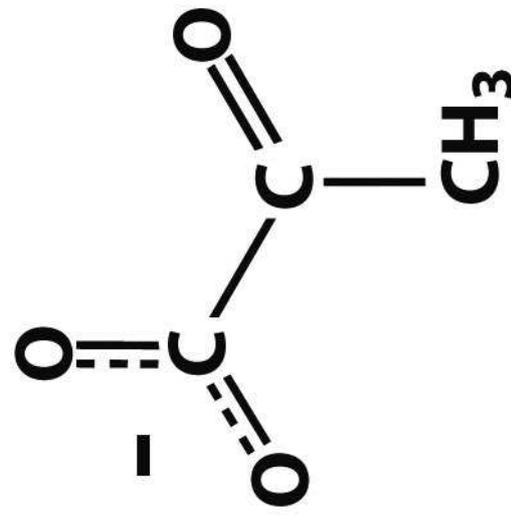
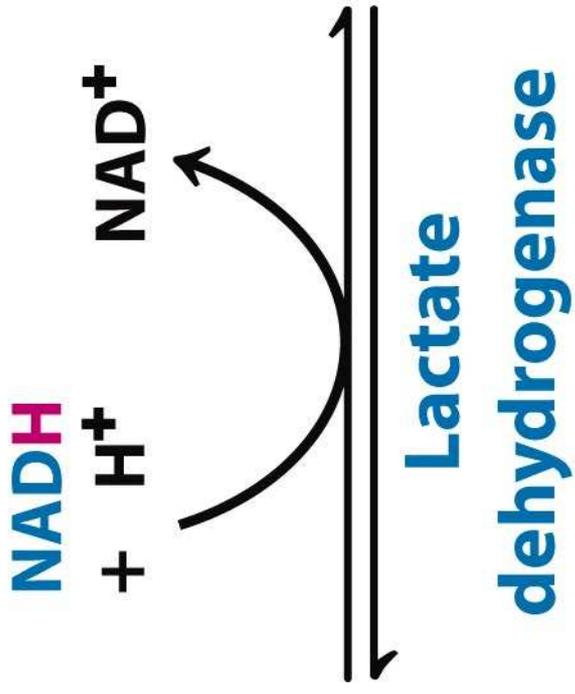
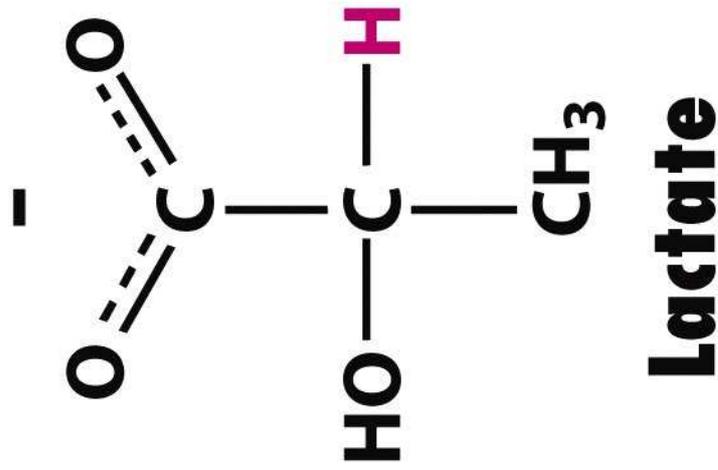


## Ethanol

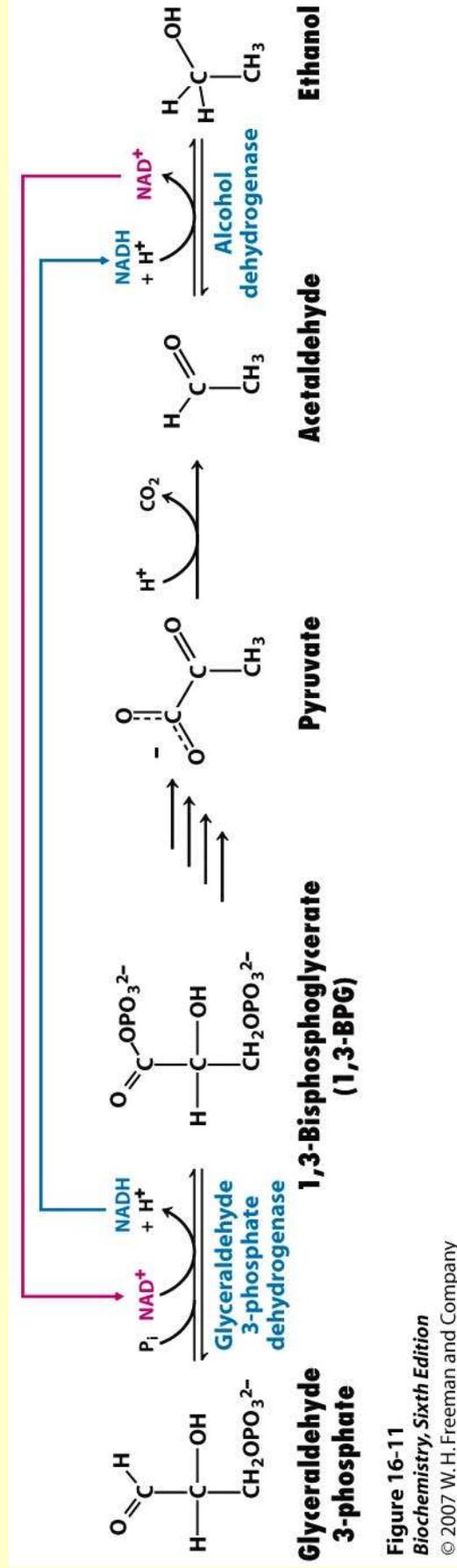
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**Figure 16-11**  
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**Reacción global de la transformación de  
glucosa en piruvato:**



**TABLE 16.3 Starting and ending points of various fermentations**

<b>Glucose</b>	↑	<b>lactate</b>
<b>Lactate</b>	↑	<b>acetate</b>
<b>Glucose</b>	↑	<b>ethanol</b>
<b>Ethanol</b>	↑	<b>acetate</b>
<b>Arginine</b>	↑	<b>carbon dioxide</b>
<b>Pyrimidines</b>	↑	<b>carbon dioxide</b>
<b>Purines</b>	↑	<b>formate</b>
<b>Ethylene glycol</b>	↑	<b>acetate</b>
<b>Threonine</b>	↑	<b>propionate</b>
<b>Leucine</b>	↑	<b>2-alkylacetate</b>
<b>Phenylalanine</b>	↑	<b>propionate</b>

**Note: The products of some fermentations are the substrates for others.**

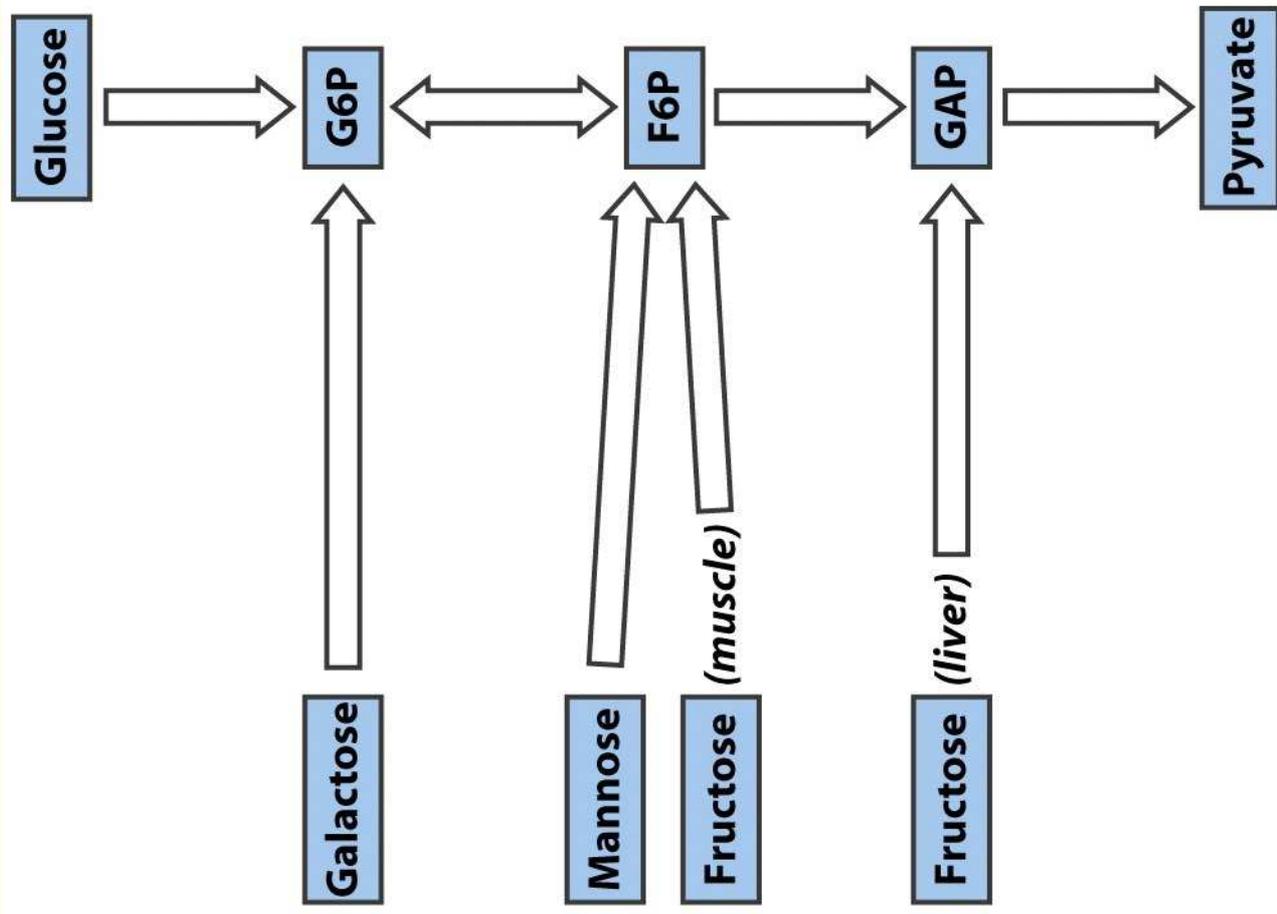


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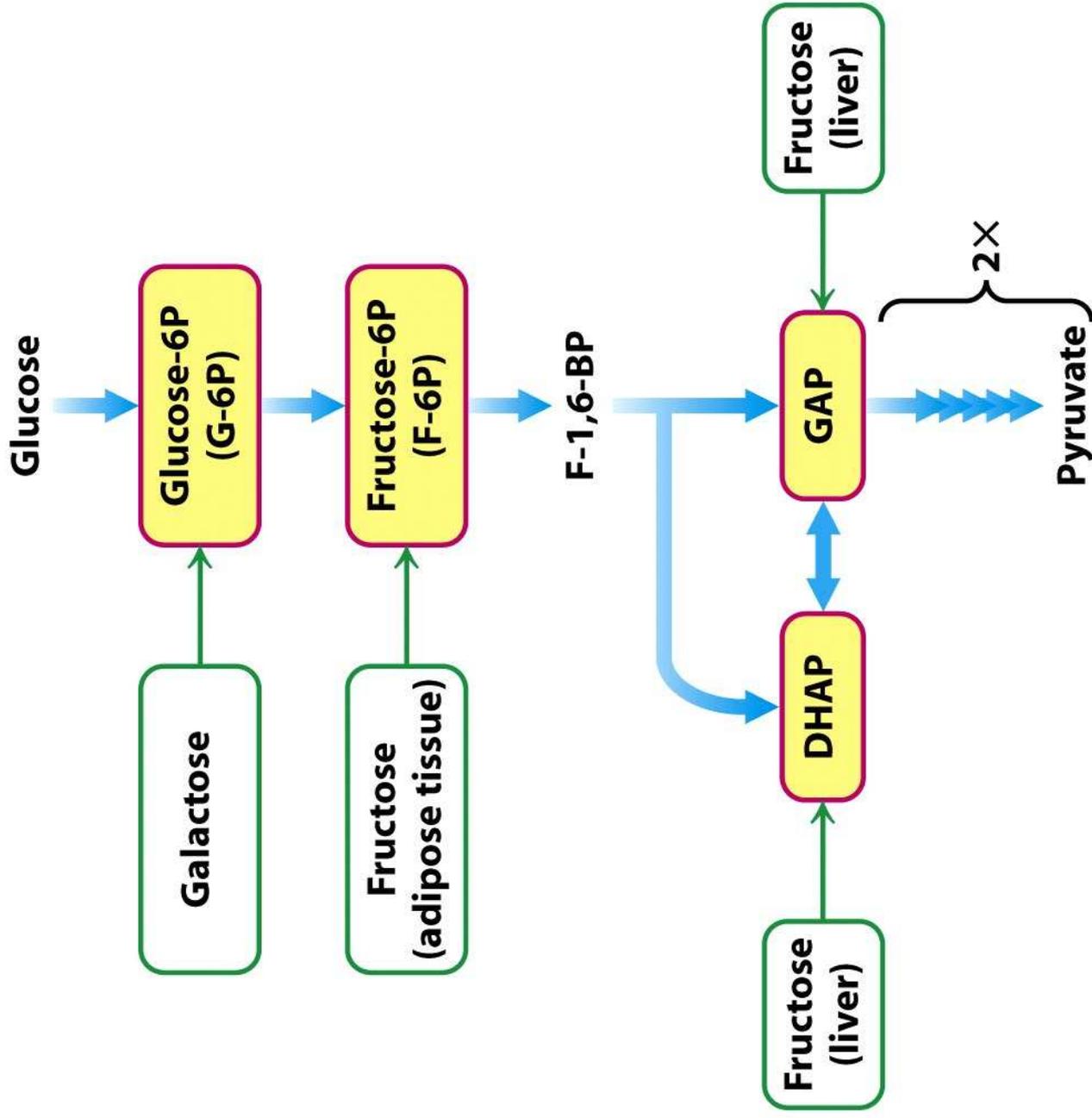
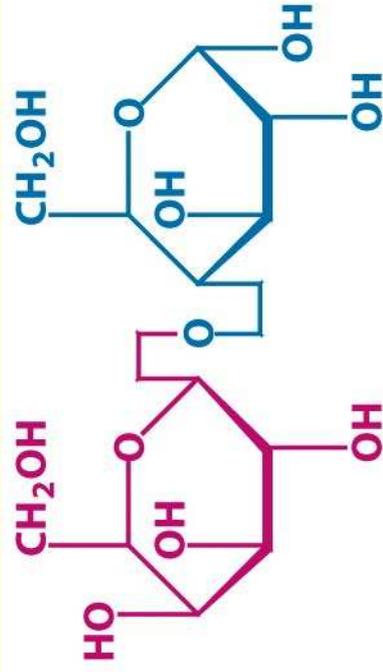
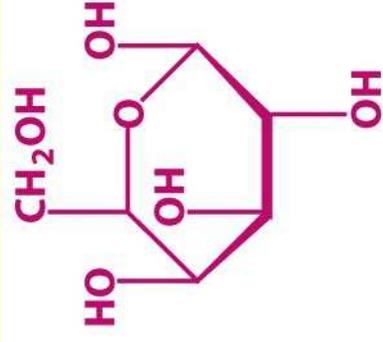


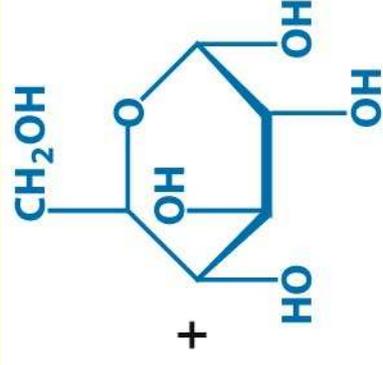
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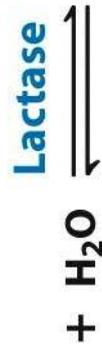
**Lactose**



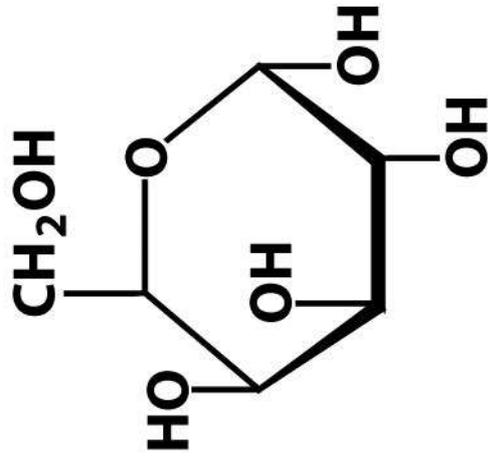
**Galactose**



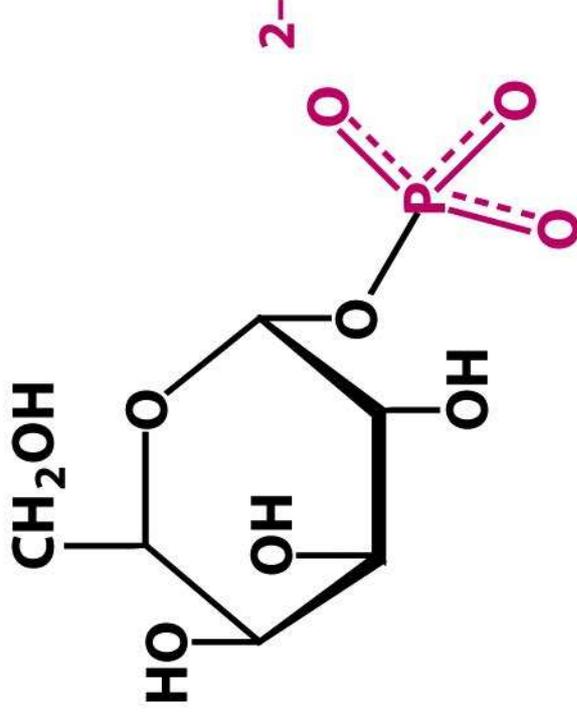
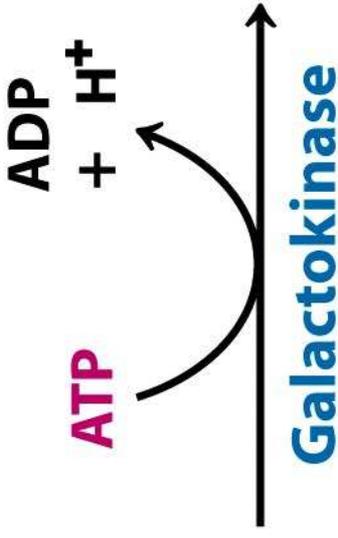
**Glucose**



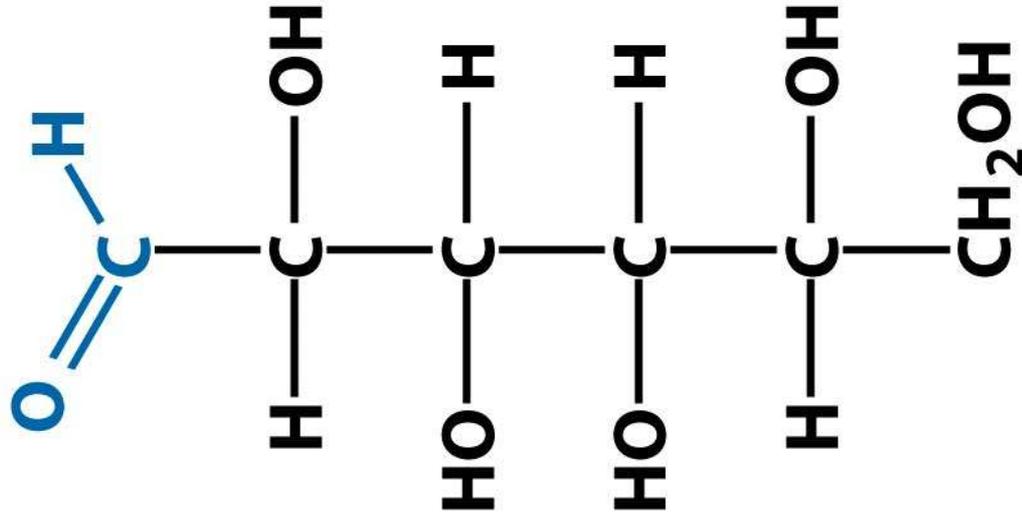
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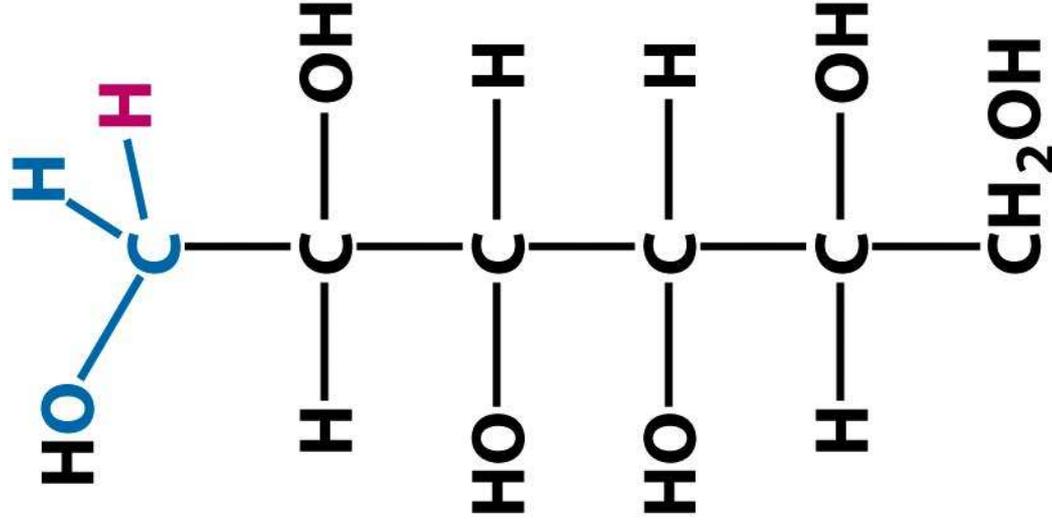
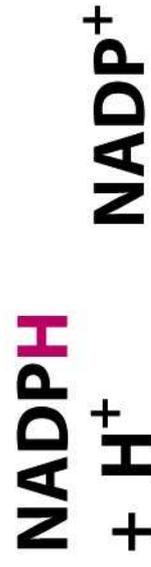
**Galactose**



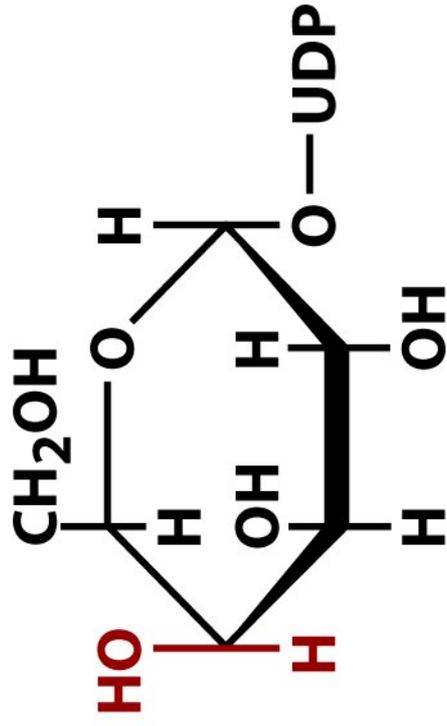
**Galactose  
1-phosphate**



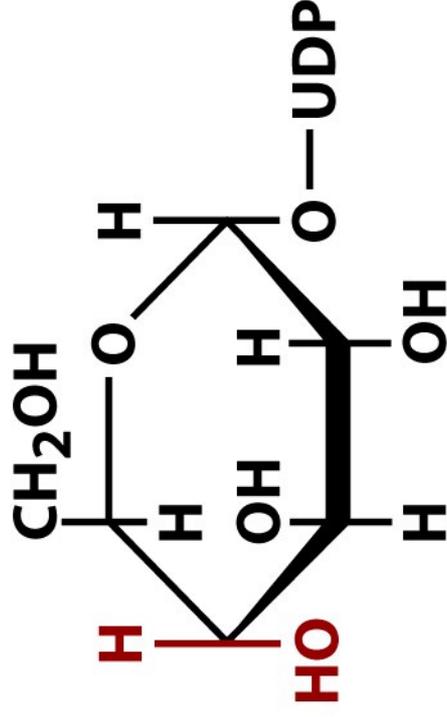
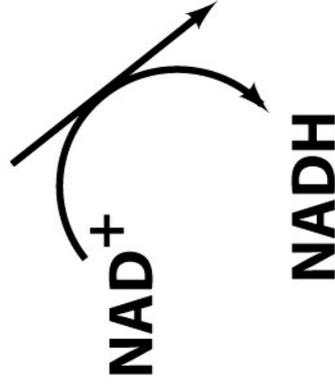
**Galactose**



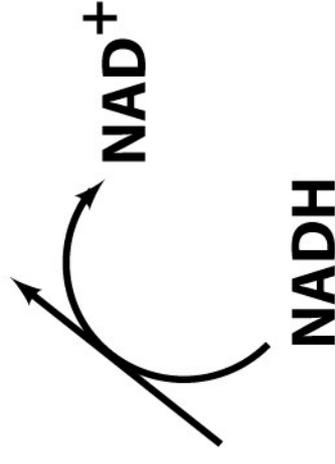
**Galactitol**

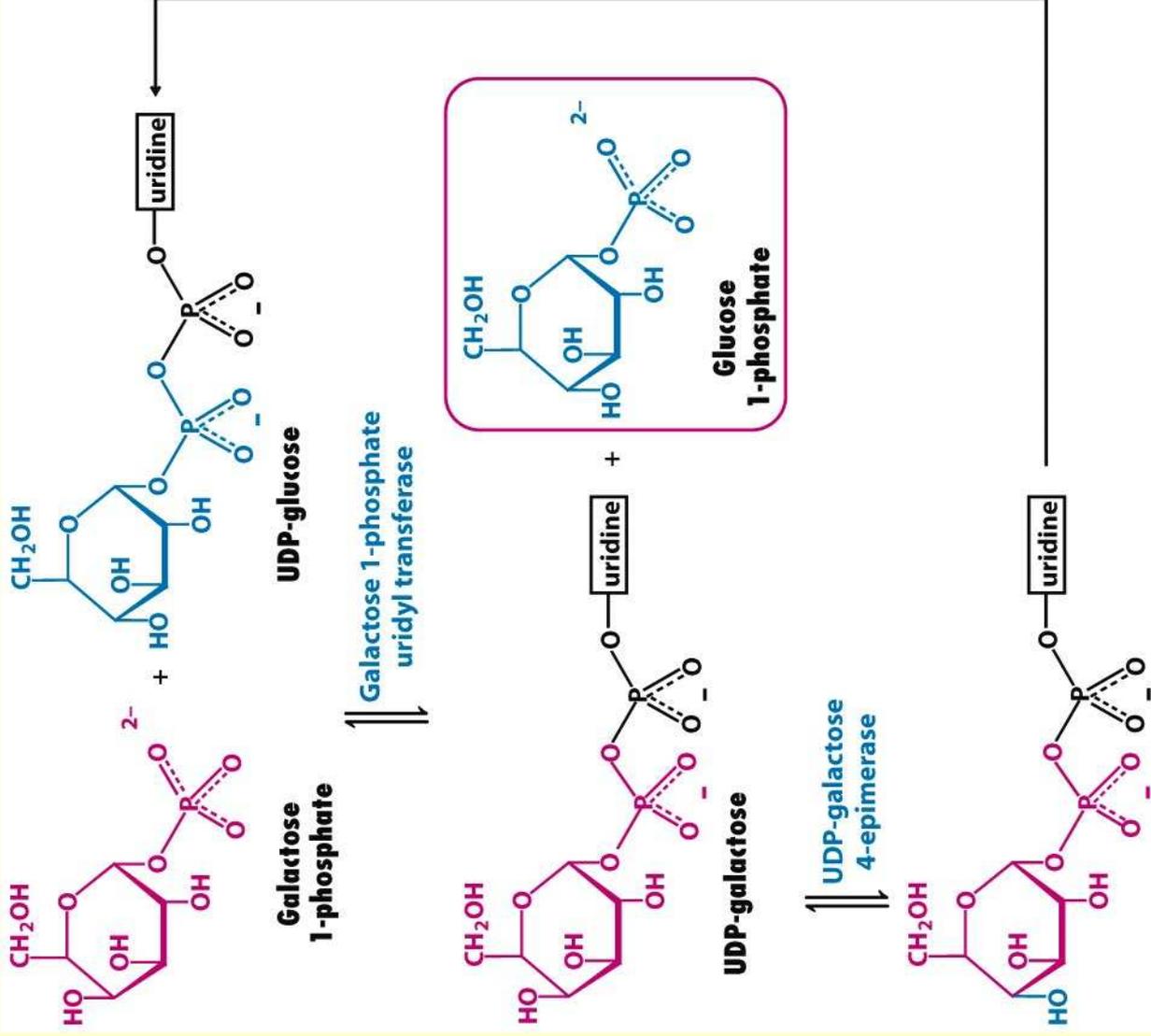


**UDP-Galactose**



**UDP-Glucose**





**UDP-glucose**

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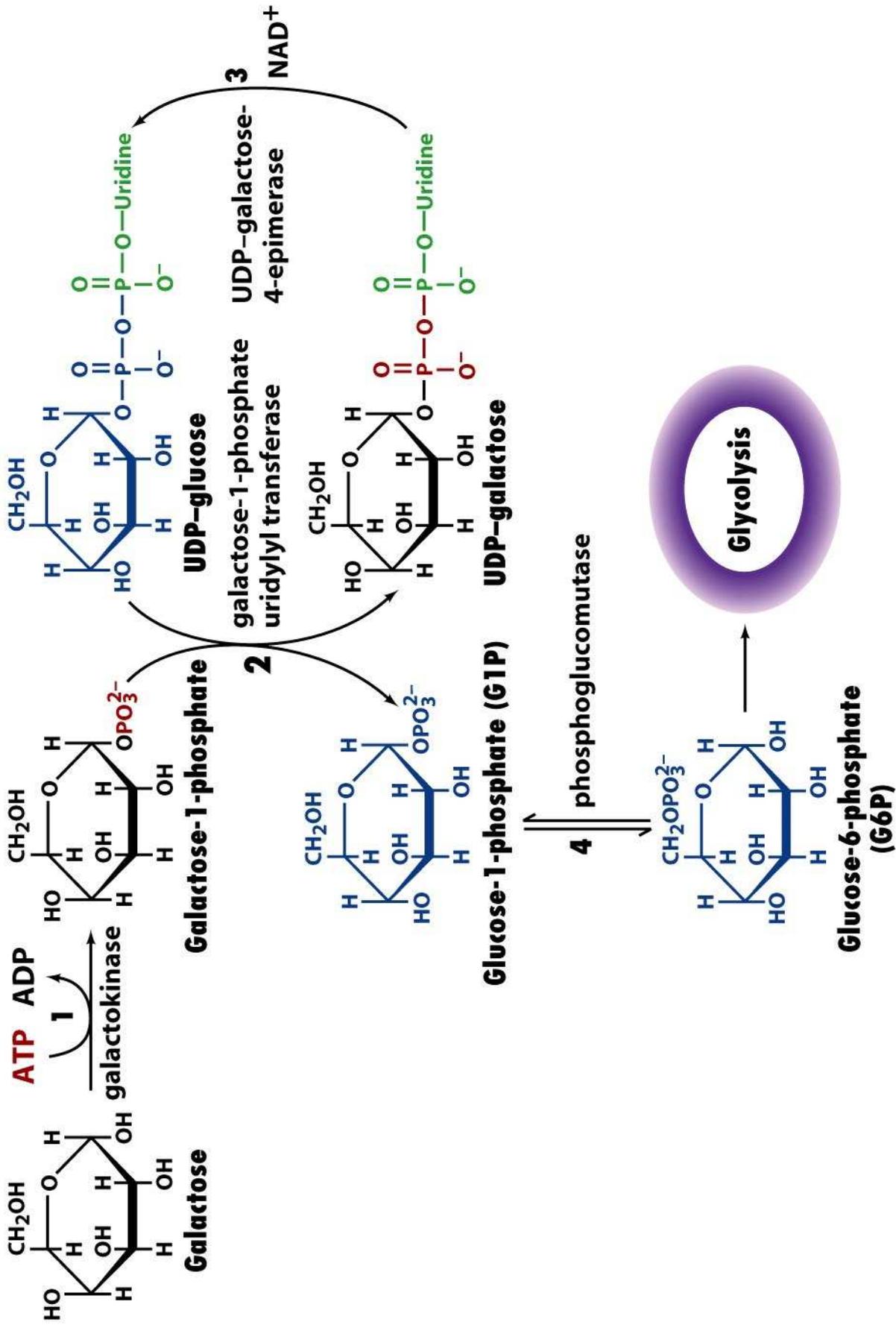
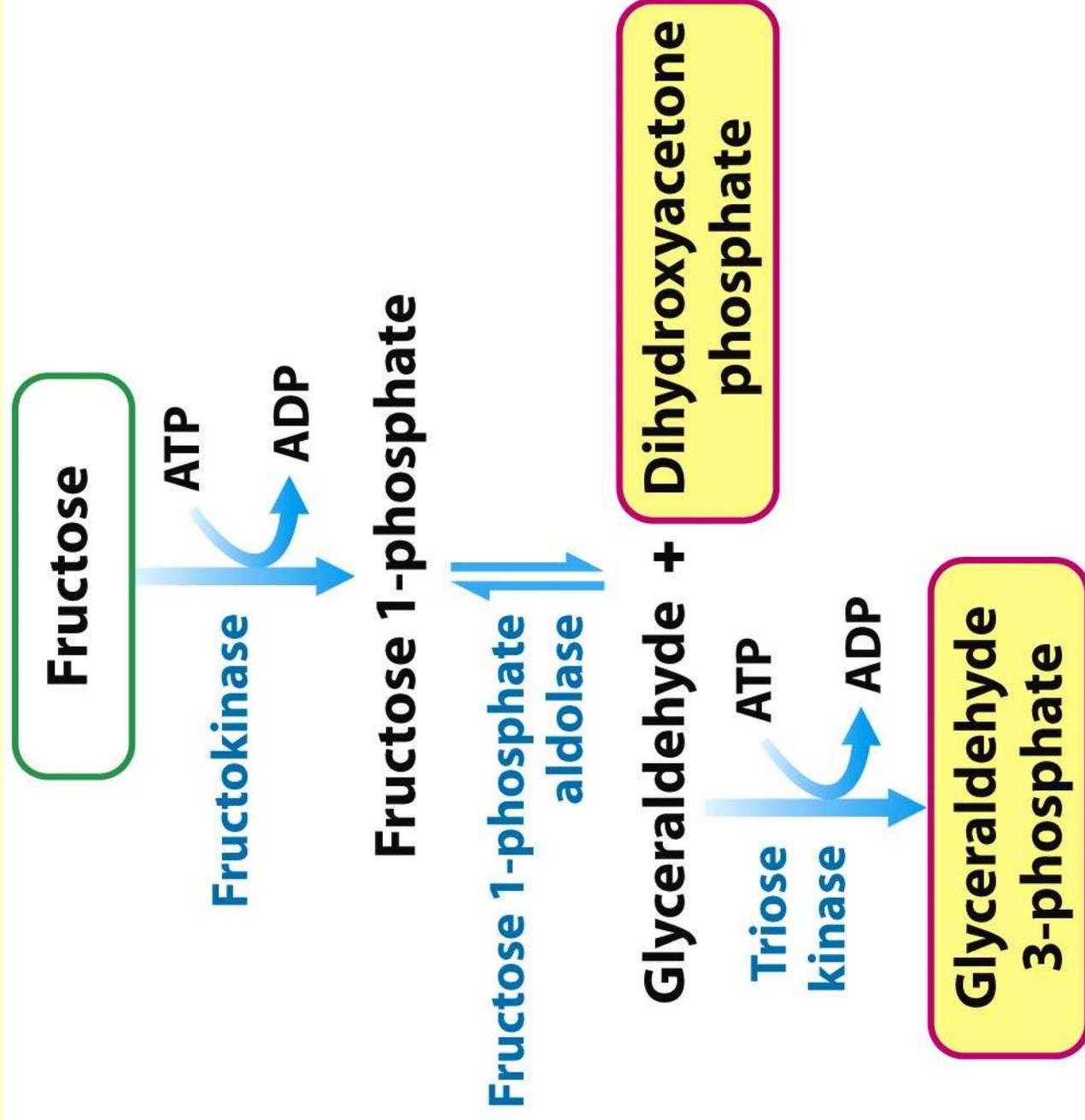


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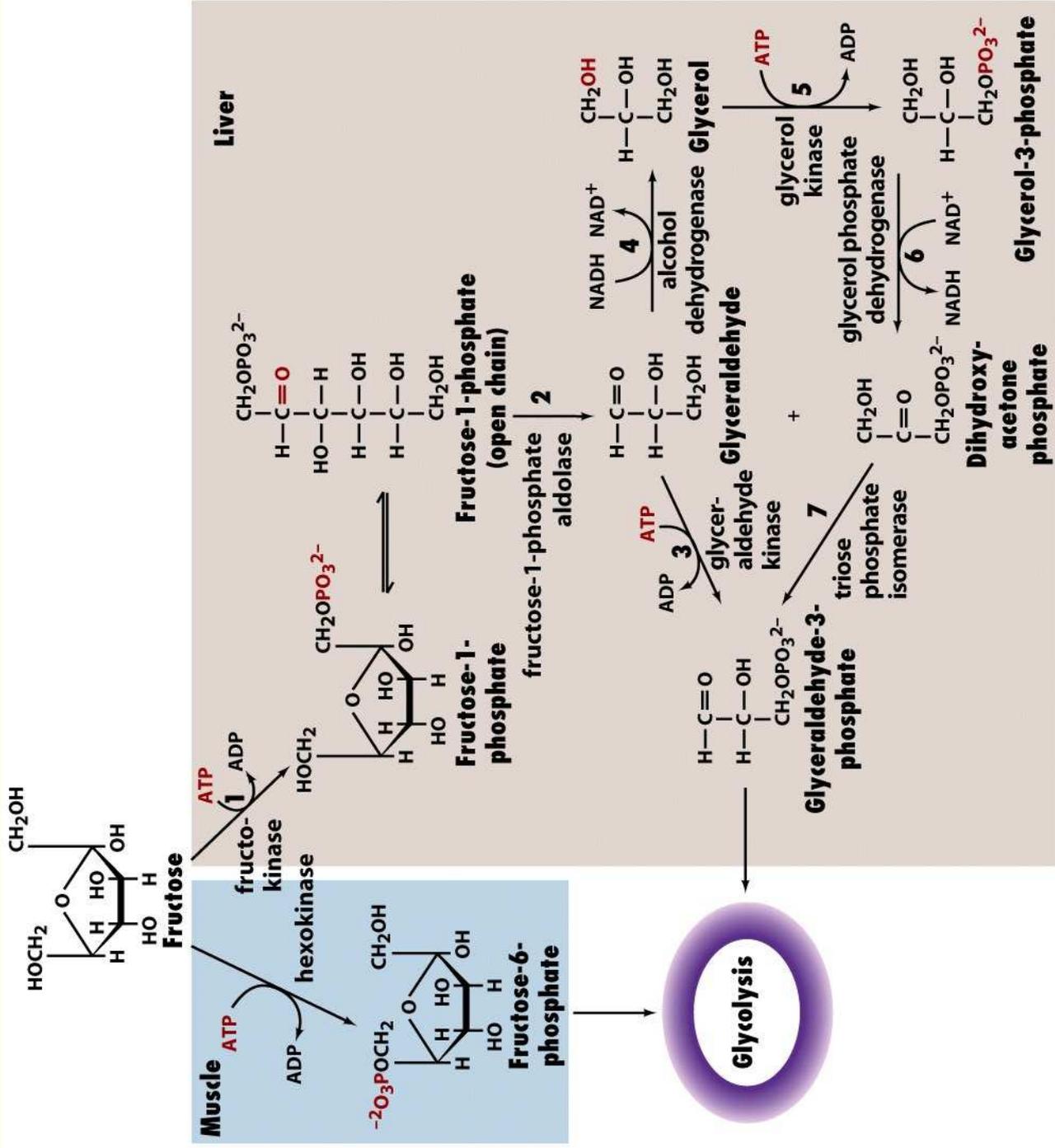


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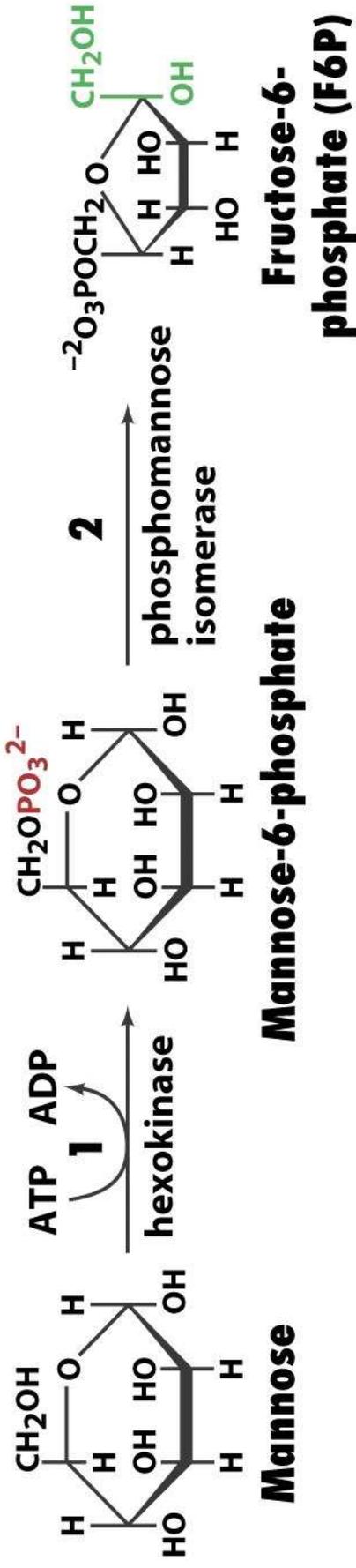
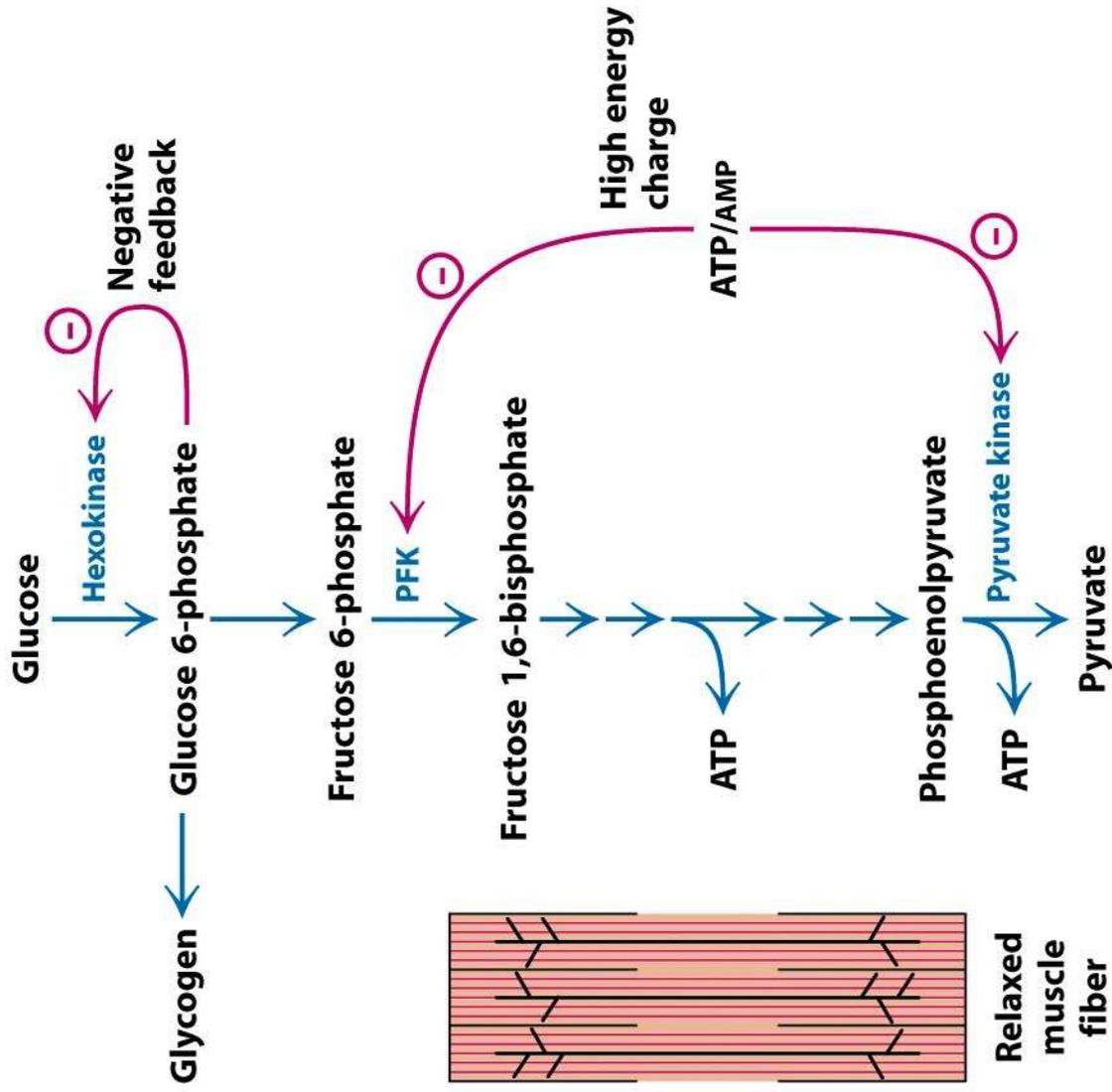


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**AT REST**  
(glycolysis inhibited)



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**DURING EXERCISE**  
(glycolysis stimulated)

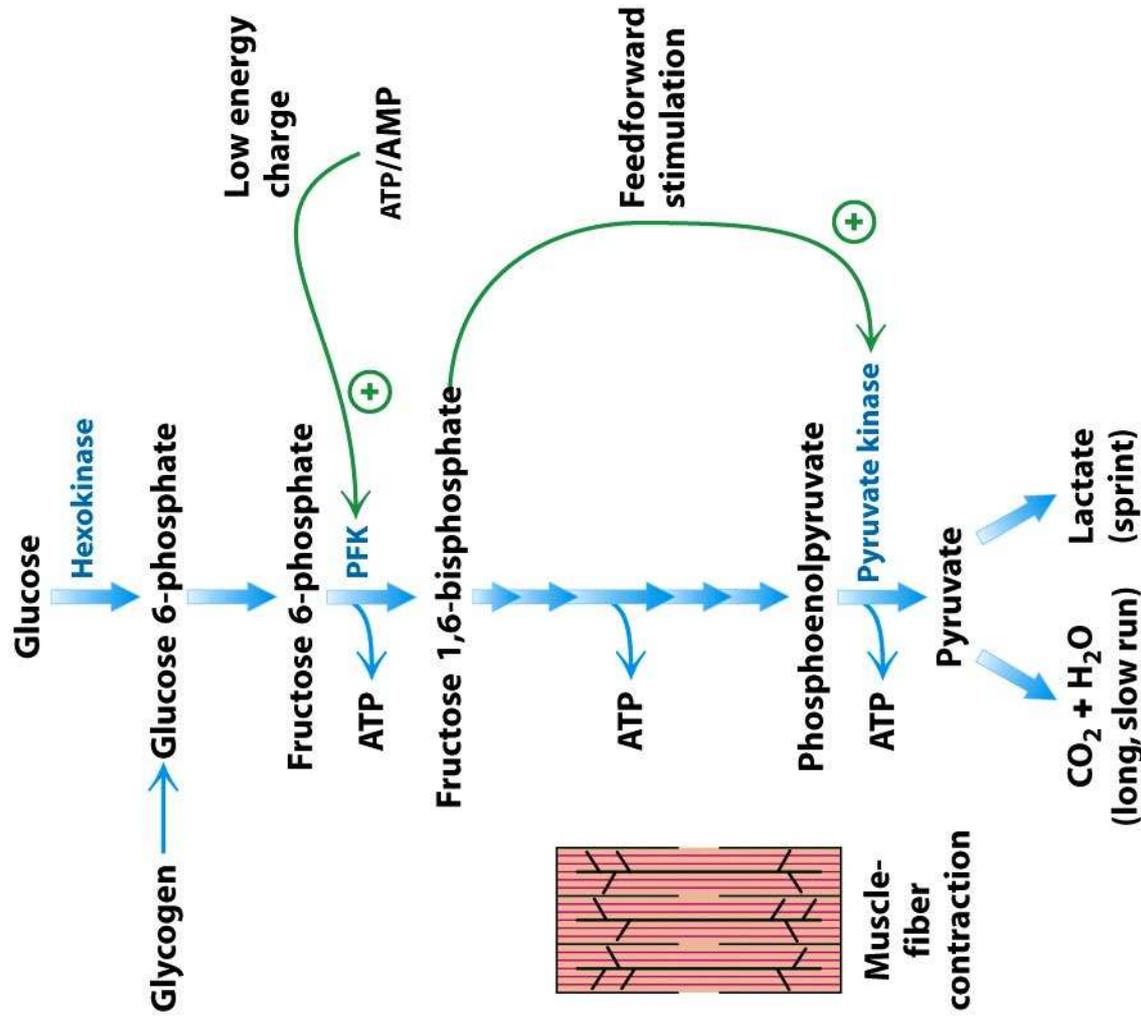
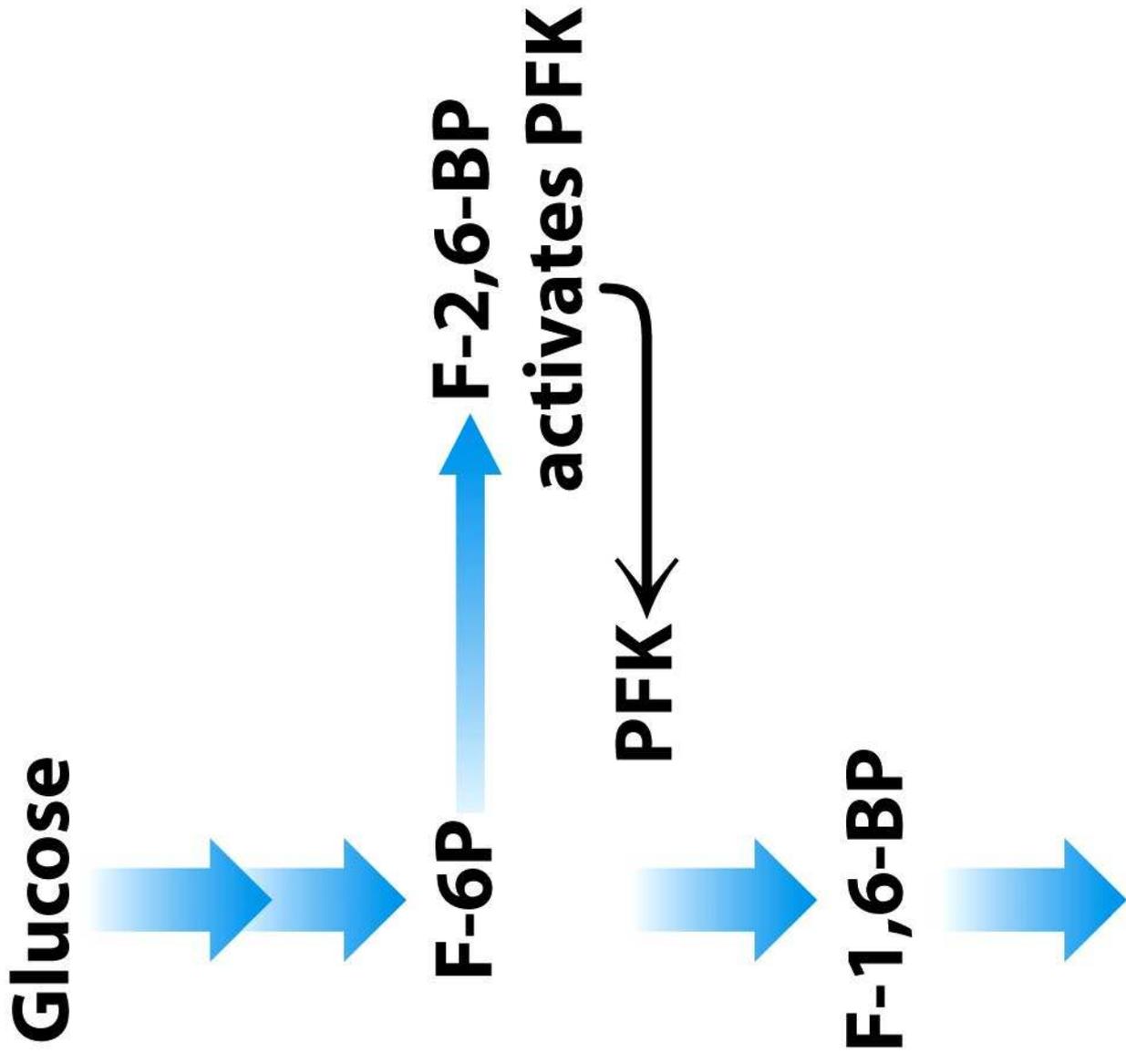
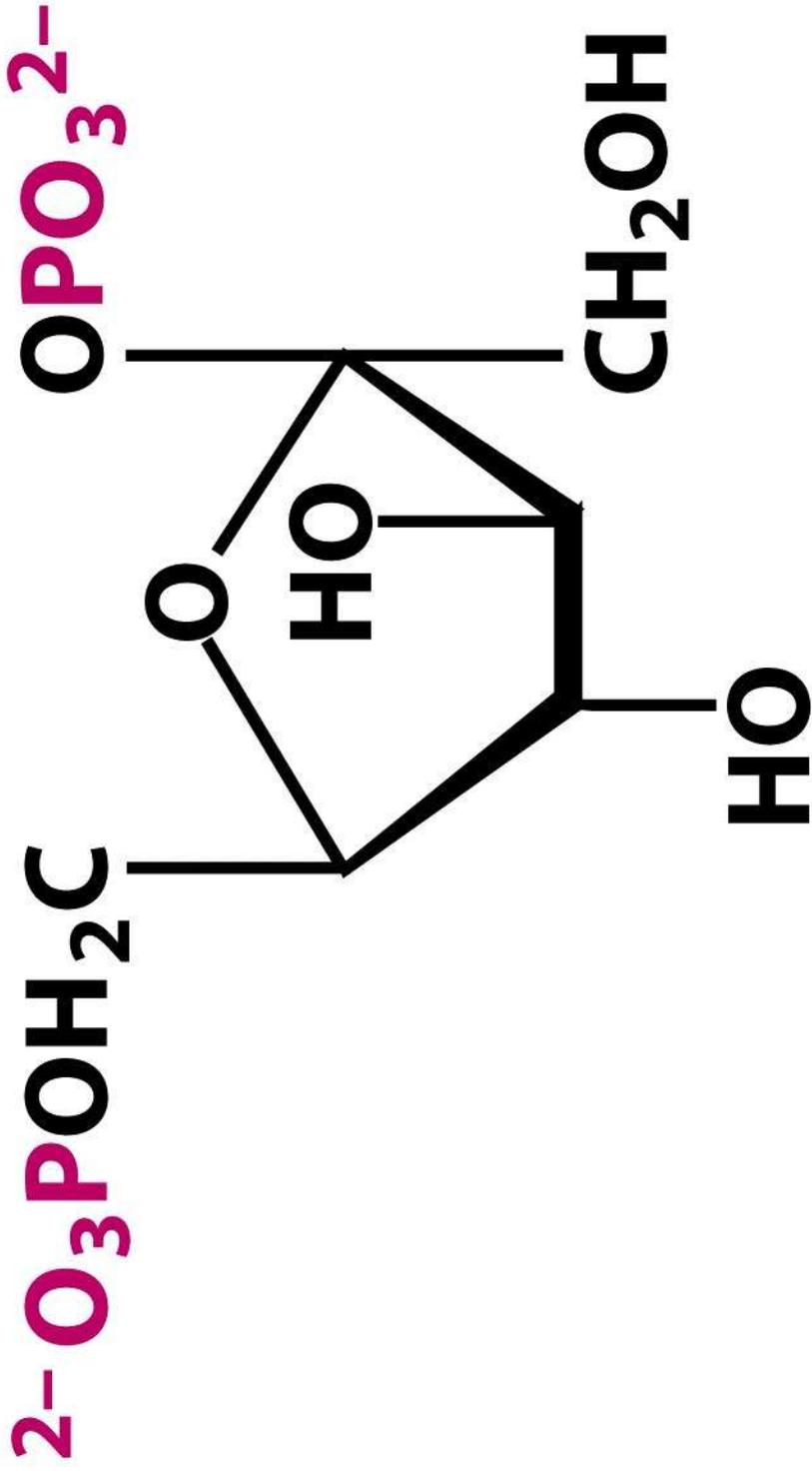


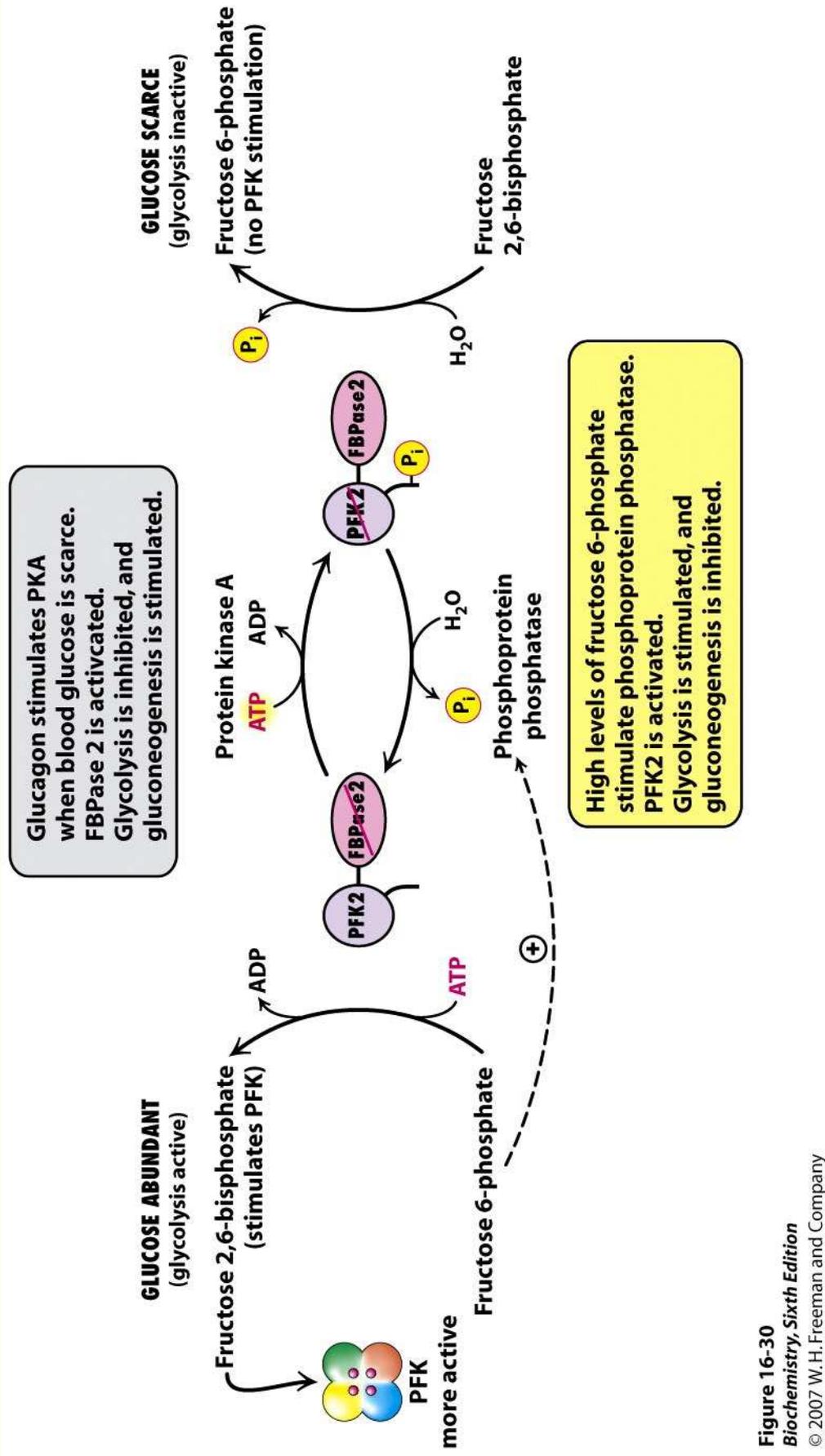
Figure 16-17 part 2  
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**Figure 16-19**  
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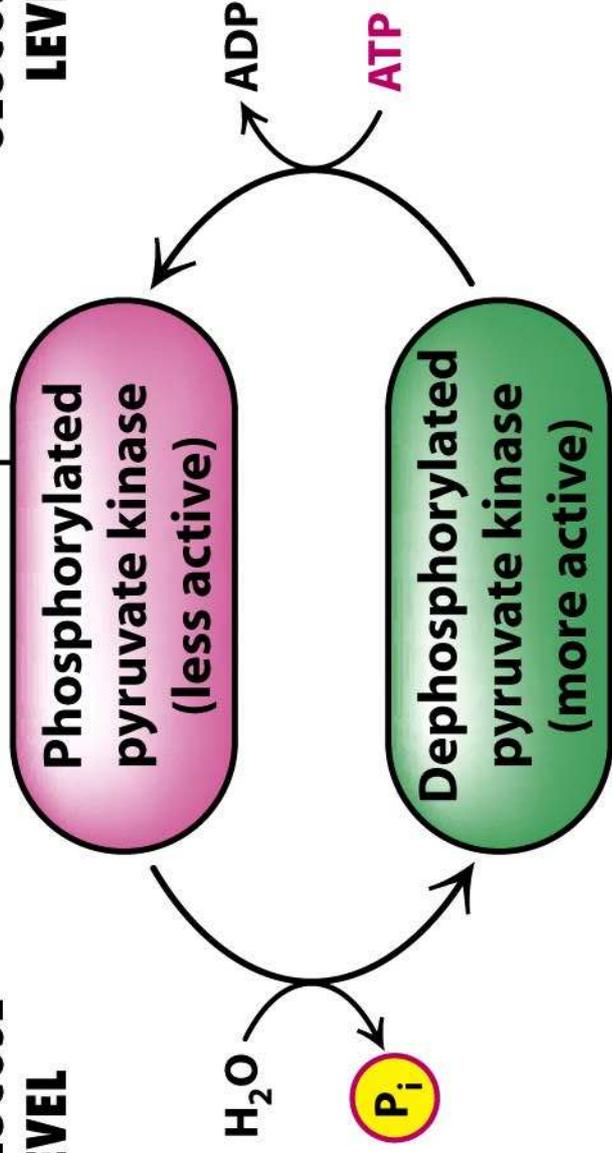
# Fructose 2,6-bisphosphate (F-2,6-BP)



**Figure 16-30**  
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**HIGH BLOOD-  
GLUCOSE  
LEVEL**

**LOW BLOOD-  
GLUCOSE  
LEVEL**



**Phosphoenolpyruvate + ADP + H<sup>+</sup> → Pyruvate + ATP**

**+**

**Fructose**

**1,6-bisphosphate**

**-**

**ATP**

**Alanine**

Figure 16-20  
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