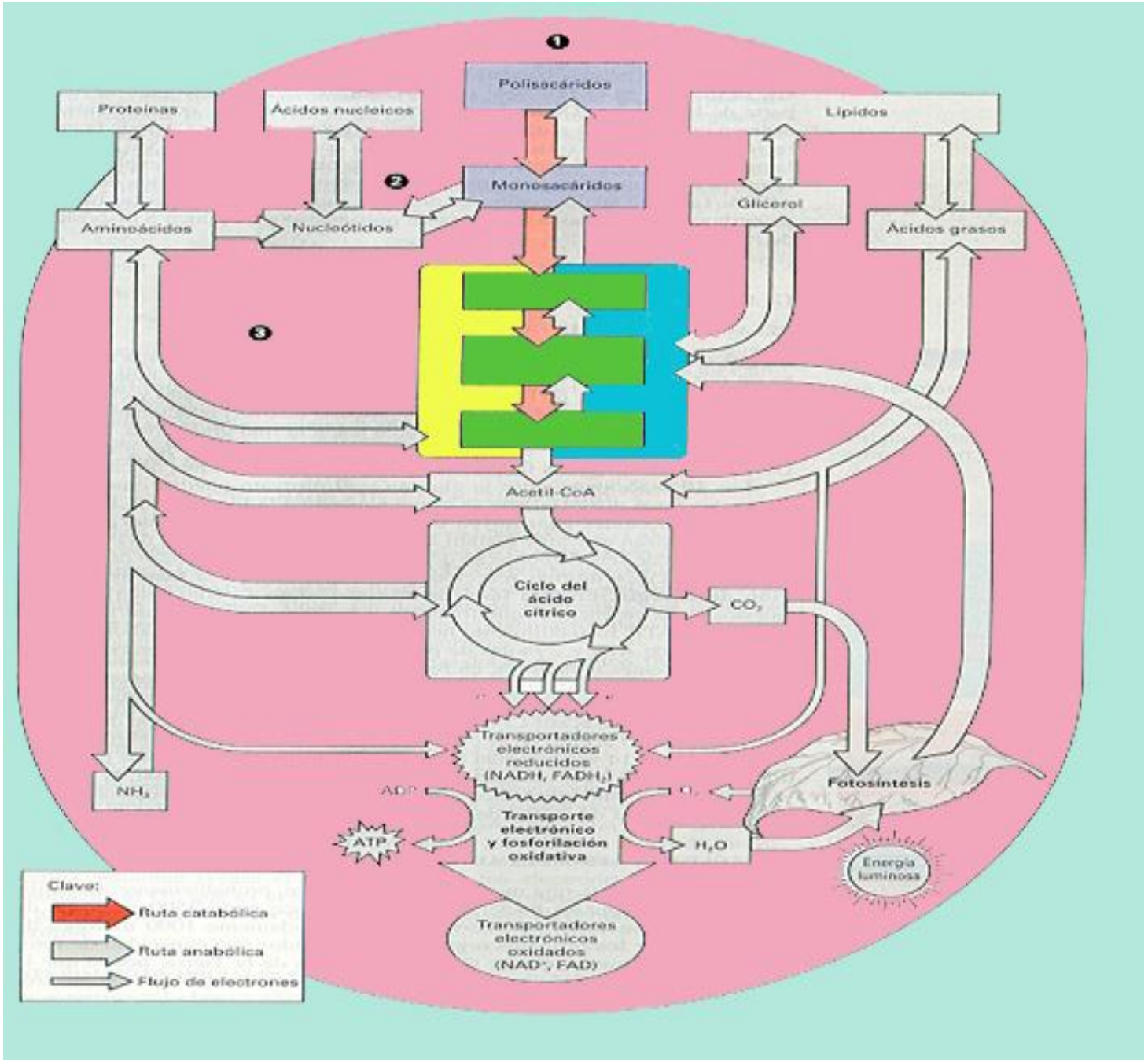
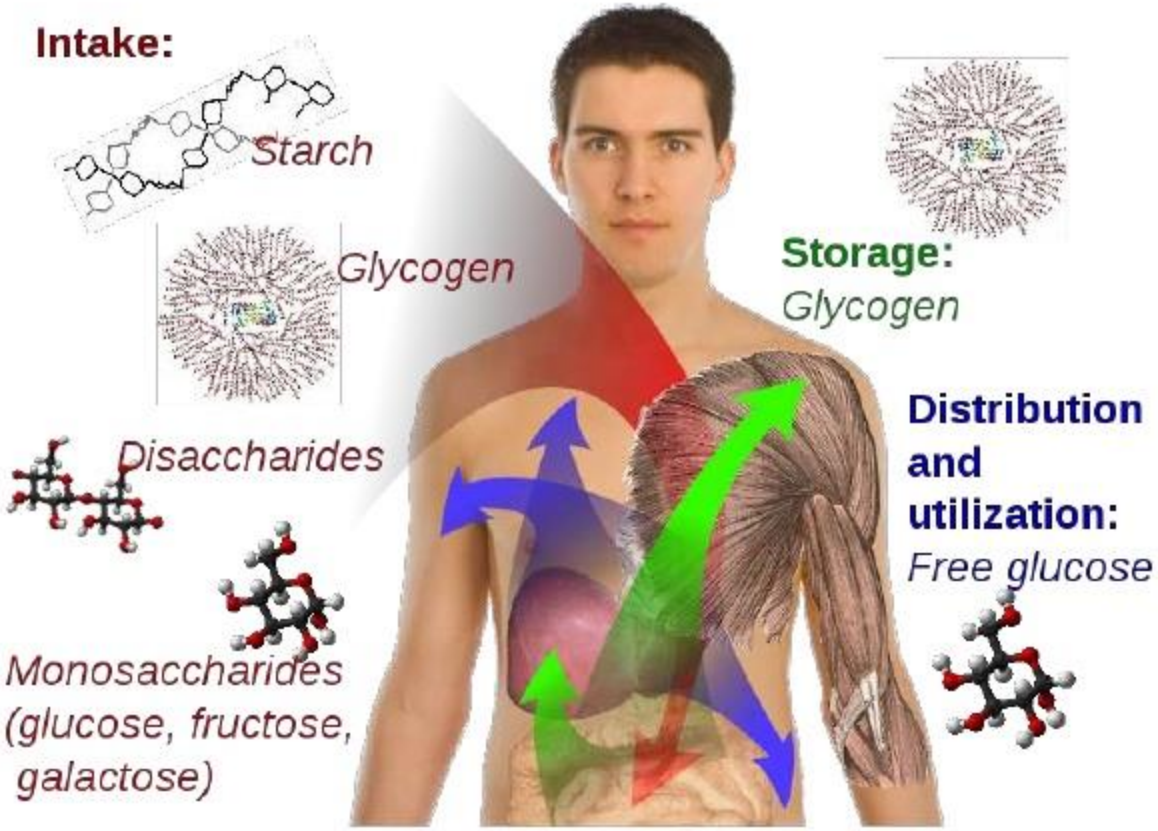
BLOQUE III:
Tema 12. CATABOLISMO DE GLÚCIDOS

INDICE

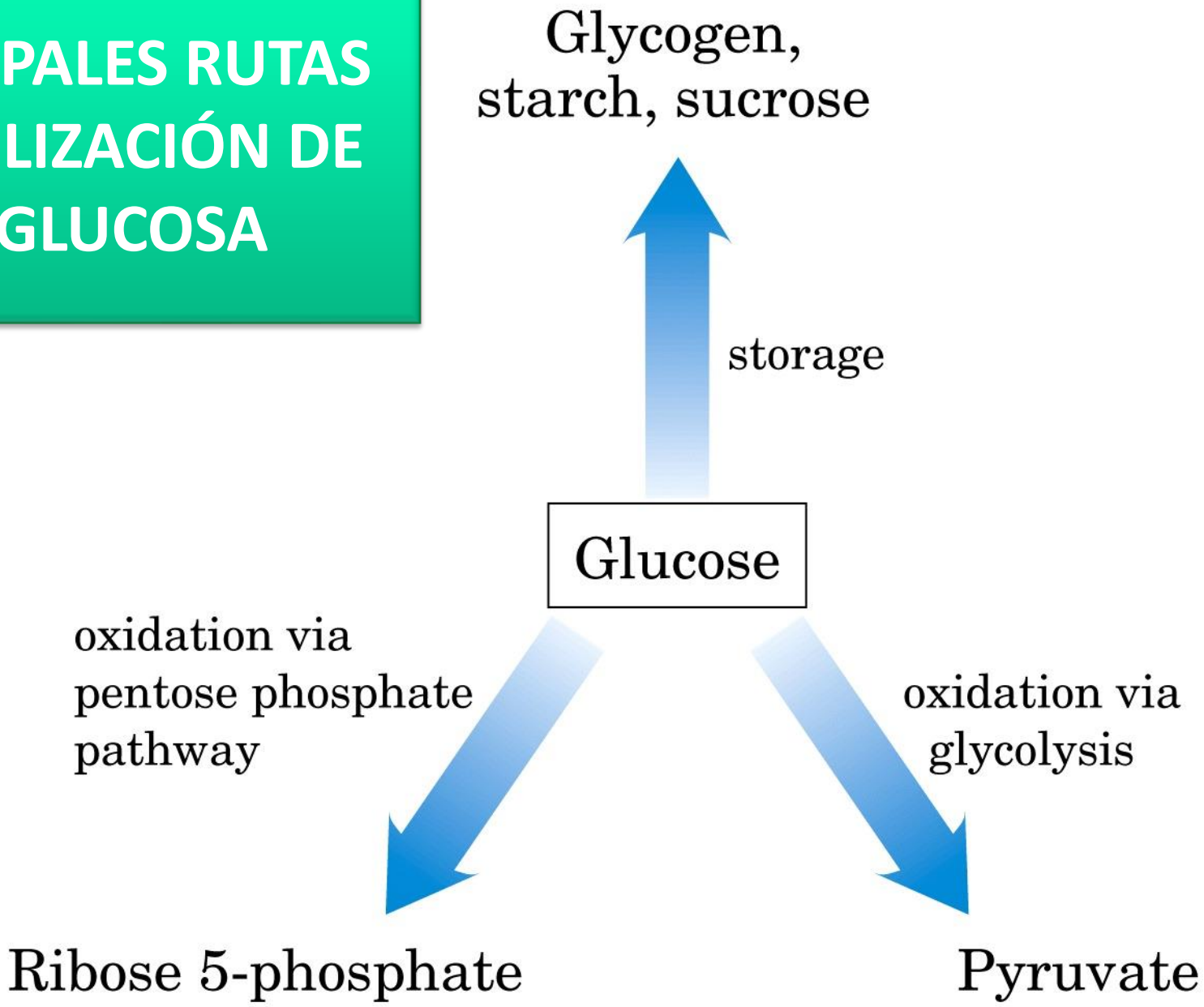
- Glucólisis
- Destinos del piruvato.
- Vía de las pentosas fosfato
- Degradación del glucógeno

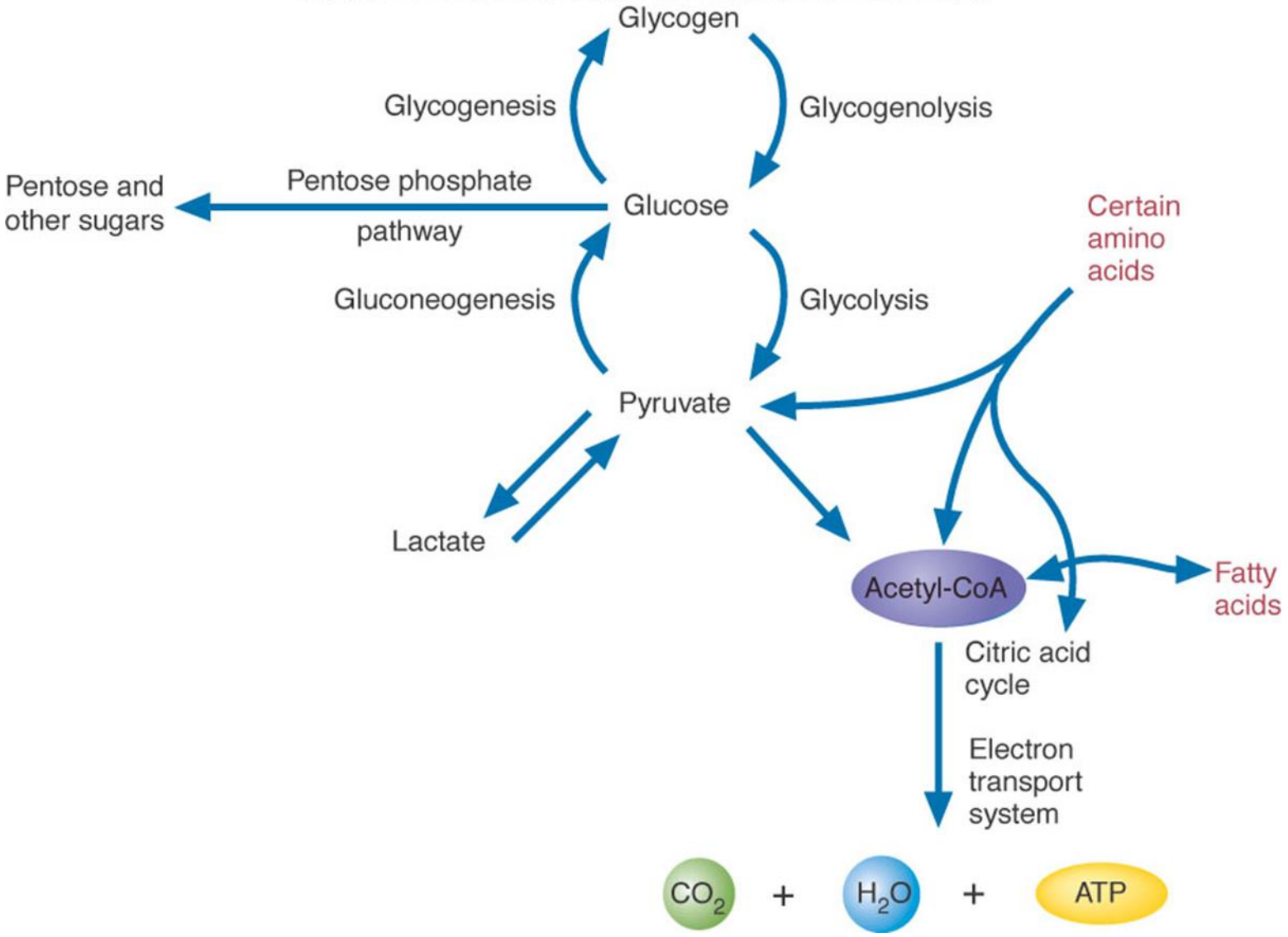

1
Polisacáridos
Proteínas
Ácidos nucleicos
Lípidos
2
Monosacáridos
Glicerol
Aminoácidos
Nucleótidos
Ácidos grasos
3
Acetil-CoA
Ciclo del ácido cítrico
CO_2
Transportadores electrónicos reducidos ($NADH$, $FADH_2$)
NH_3
ADP
ATP
Transporte electrónico y fosforilación oxidativa
O_2
H_2O
Fotosíntesis
Energía luminosa
Transportadores electrónicos oxidados (NAD^+, FAD)
Clave:
Ruta catabólica
Ruta anabólica
Flujo de electrones

Glucose metabolism

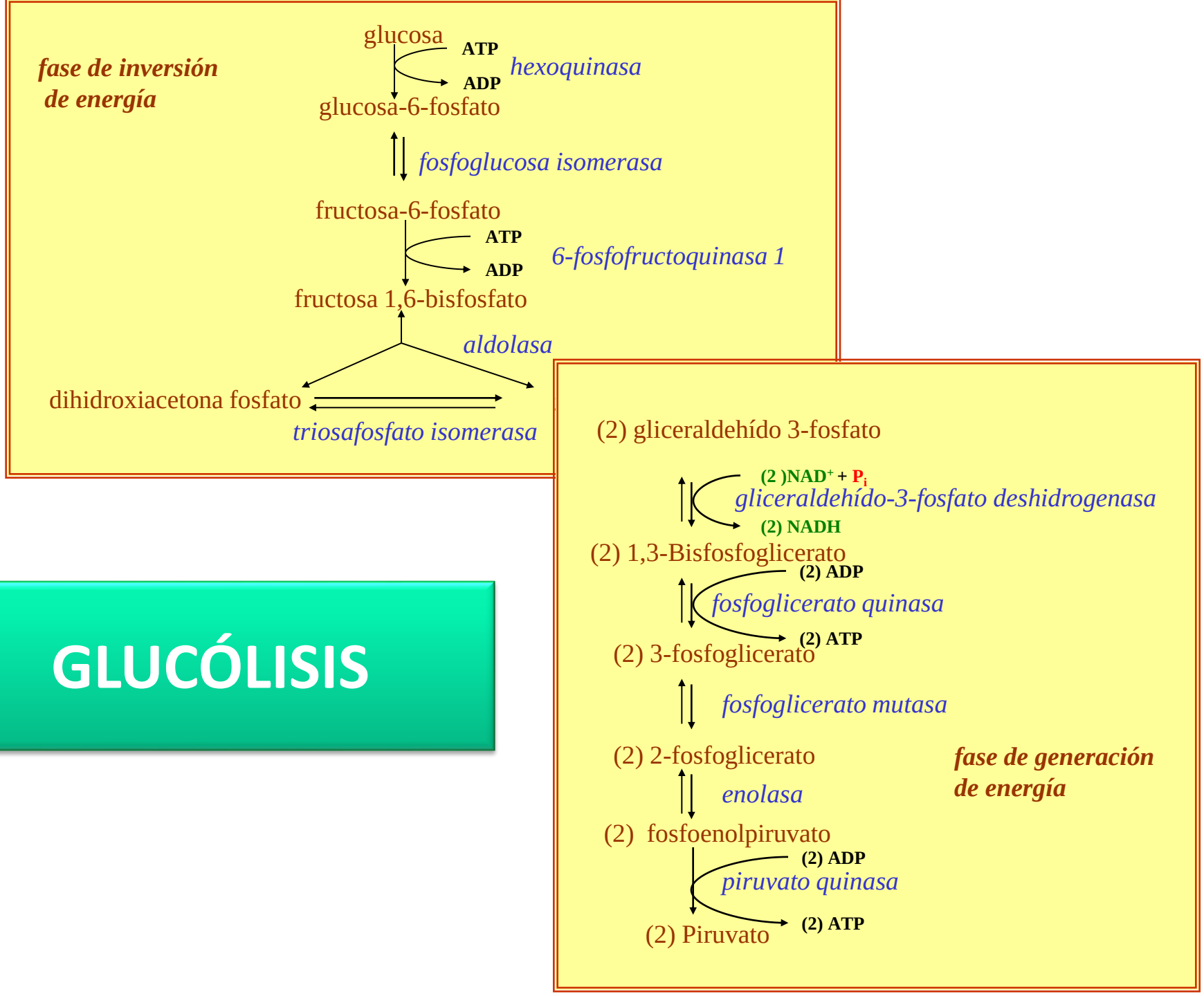


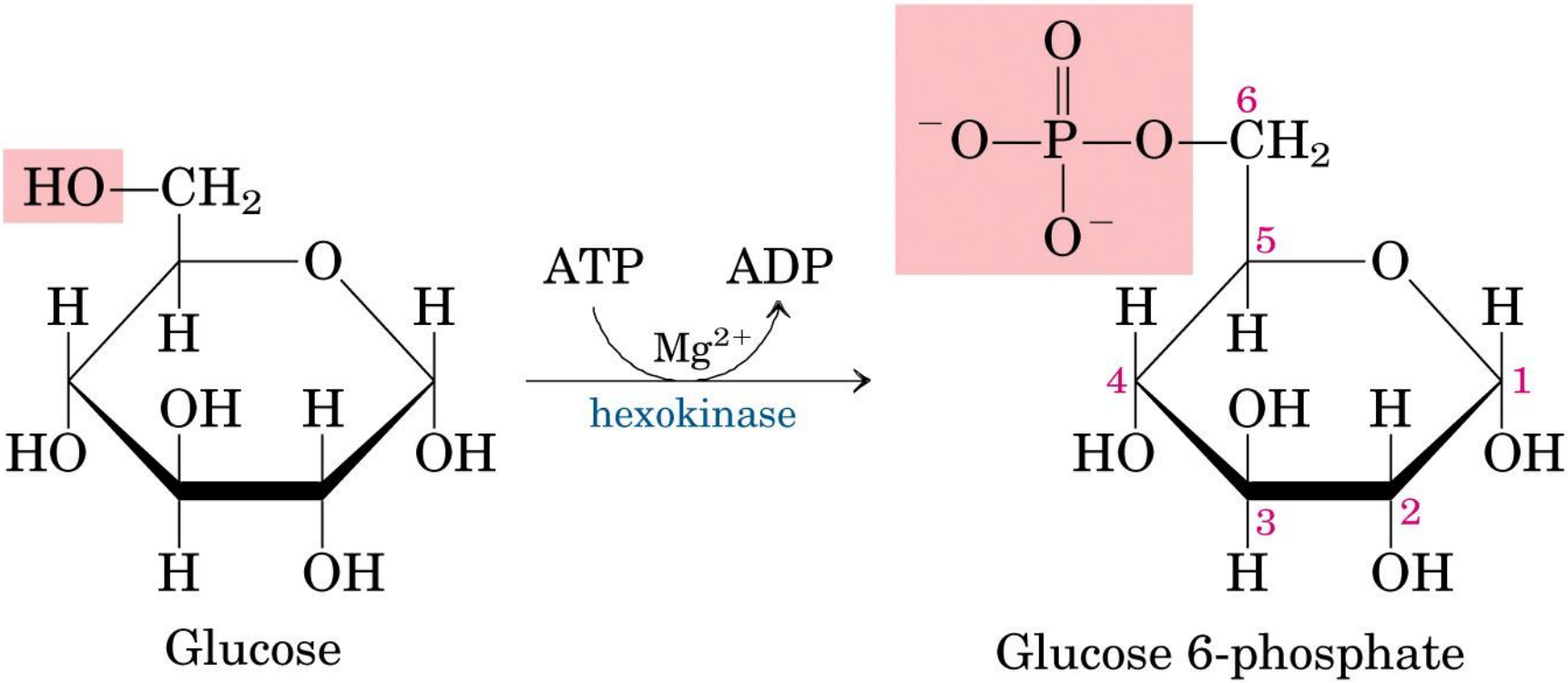
PRINCIPALES RUTAS DE UTILIZACIÓN DE LA GLUCOSA





GLUCÓLISIS


fase de inversión de energía
glucosa
ATP
ADP
hexoquinasa
glucosa-6-fosfato
fosfoglucosa isomerasa
fructosa-6-fosfato
ATP
ADP
6-fosfofructoquinasa 1
fructosa 1,6-bisfosfato
aldolasa
dihidroxiacetona fosfato
triosafosfato isomerasa
(2) gliceraldehído 3-fosfato
(2)NAD+ + Pi
gliceraldehído-3-fosfato deshidrogenasa
(2) NADH
(2) 1,3-Bisfosfoglicerato
(2) ADP
fosfoglicerato quinasa
(2) ATP
(2) 3-fosfoglicerato
fosfoglicerato mutasa
(2) 2-fosfoglicerato
enolasa
(2) fosfoenolpiruvato
(2) ADP
piruvato quinasa
(2) ATP
(2) Piruvato
fase de generación de energía



Glucose

Glucose 6-phosphate

$\Delta G'^{\circ} = -16.7$ kJ/mol

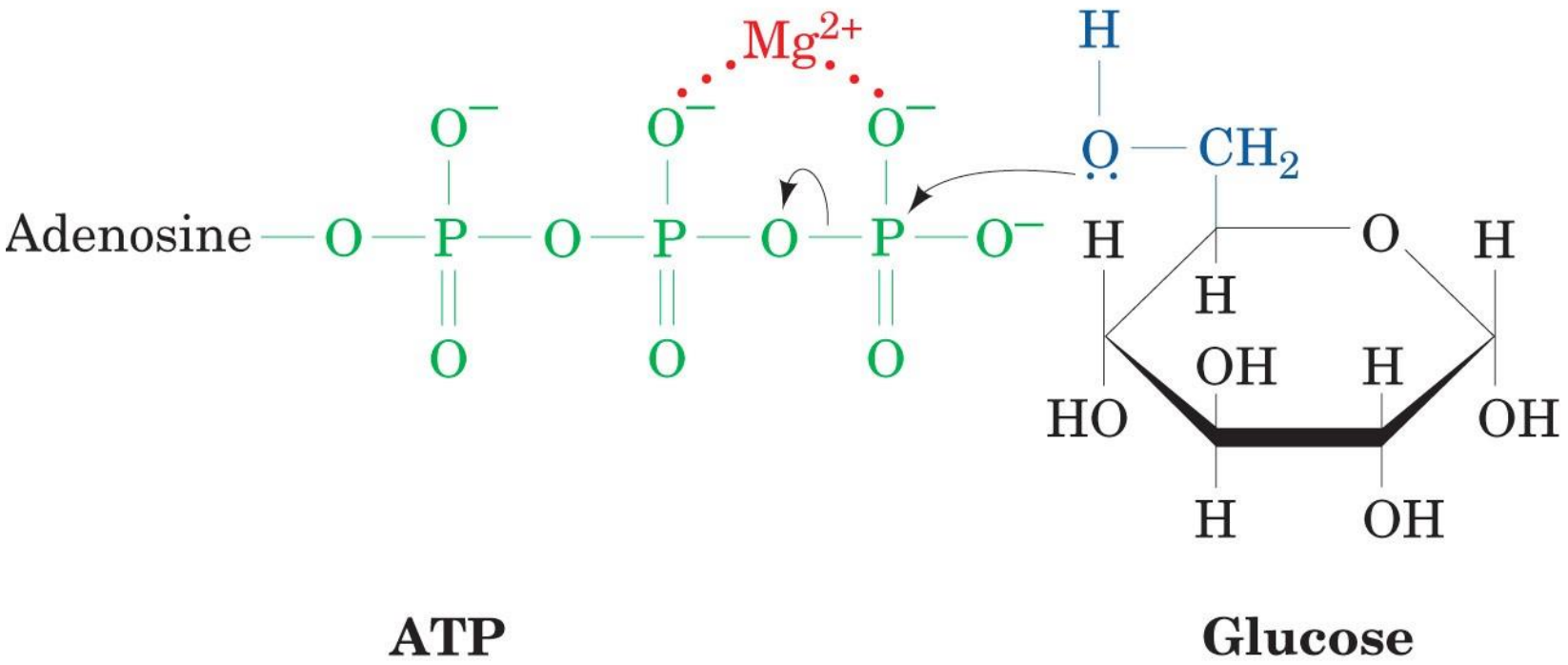
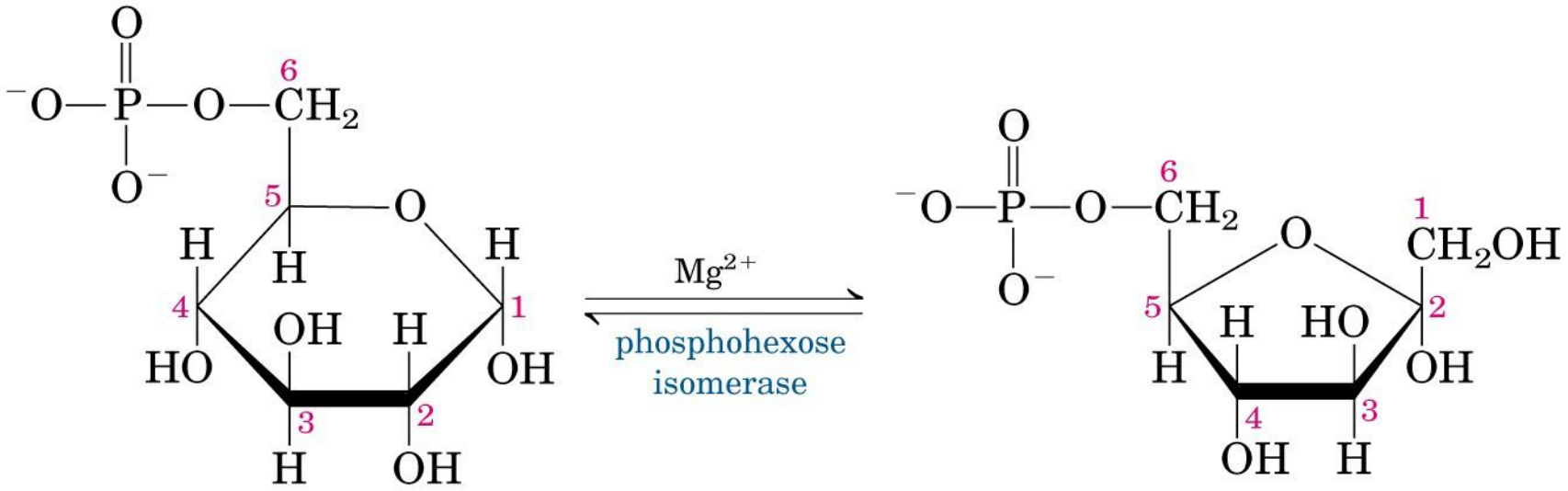


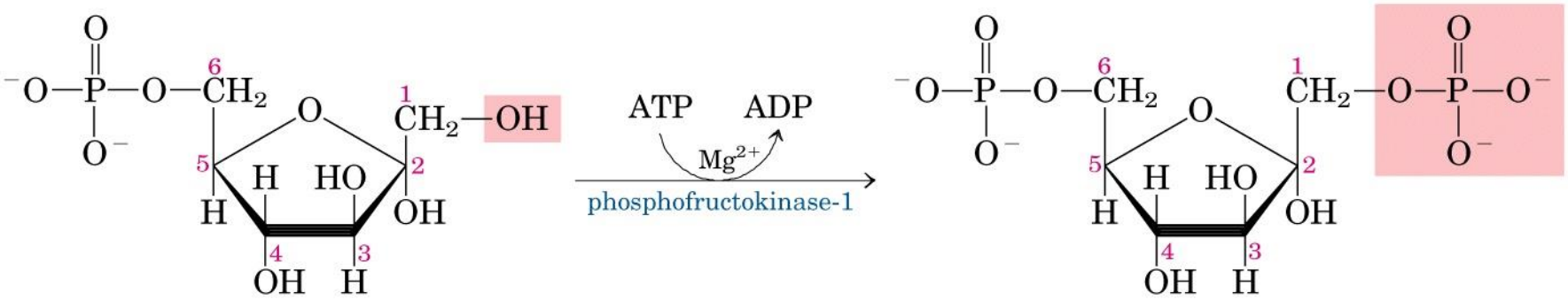
Figure 17-4 The nucleophilic attack of the C6—OH group of glucose on the γ phosphate of an Mg^{2+}–ATP complex.



Glucose 6-phosphate

Fructose 6-phosphate

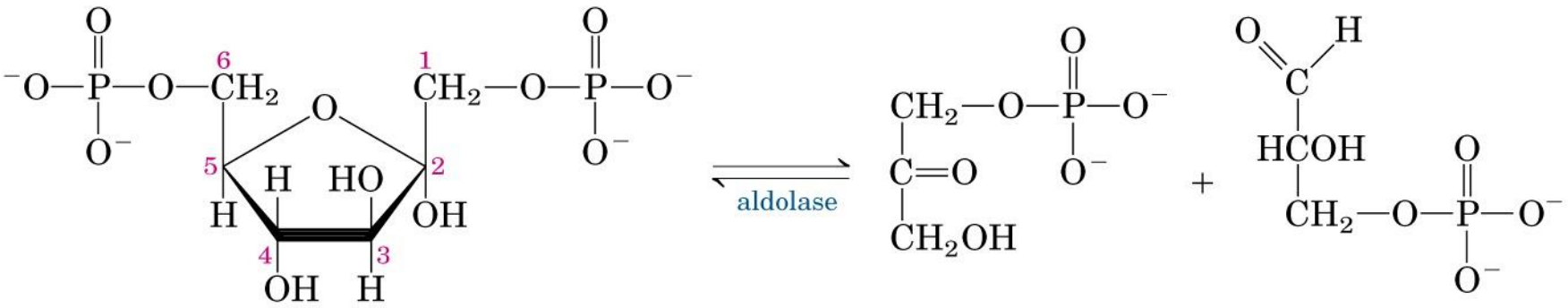
$\Delta G'^{\circ} = 1.7$ kJ/mol



Fructose 6-phosphate

Fructose 1,6-bisphosphate

$\Delta G'^{\circ} = -14.2$ kJ/mol

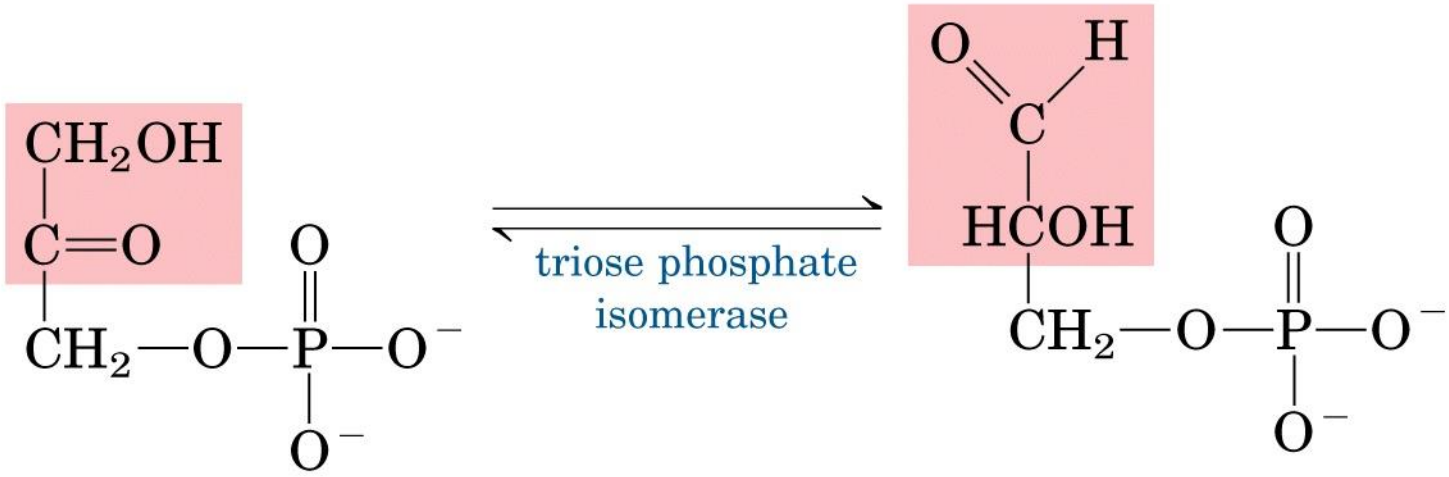


Fructose 1,6-bisphosphate

Dihydroxyacetone phosphate

Glyceraldehyde 3-phosphate

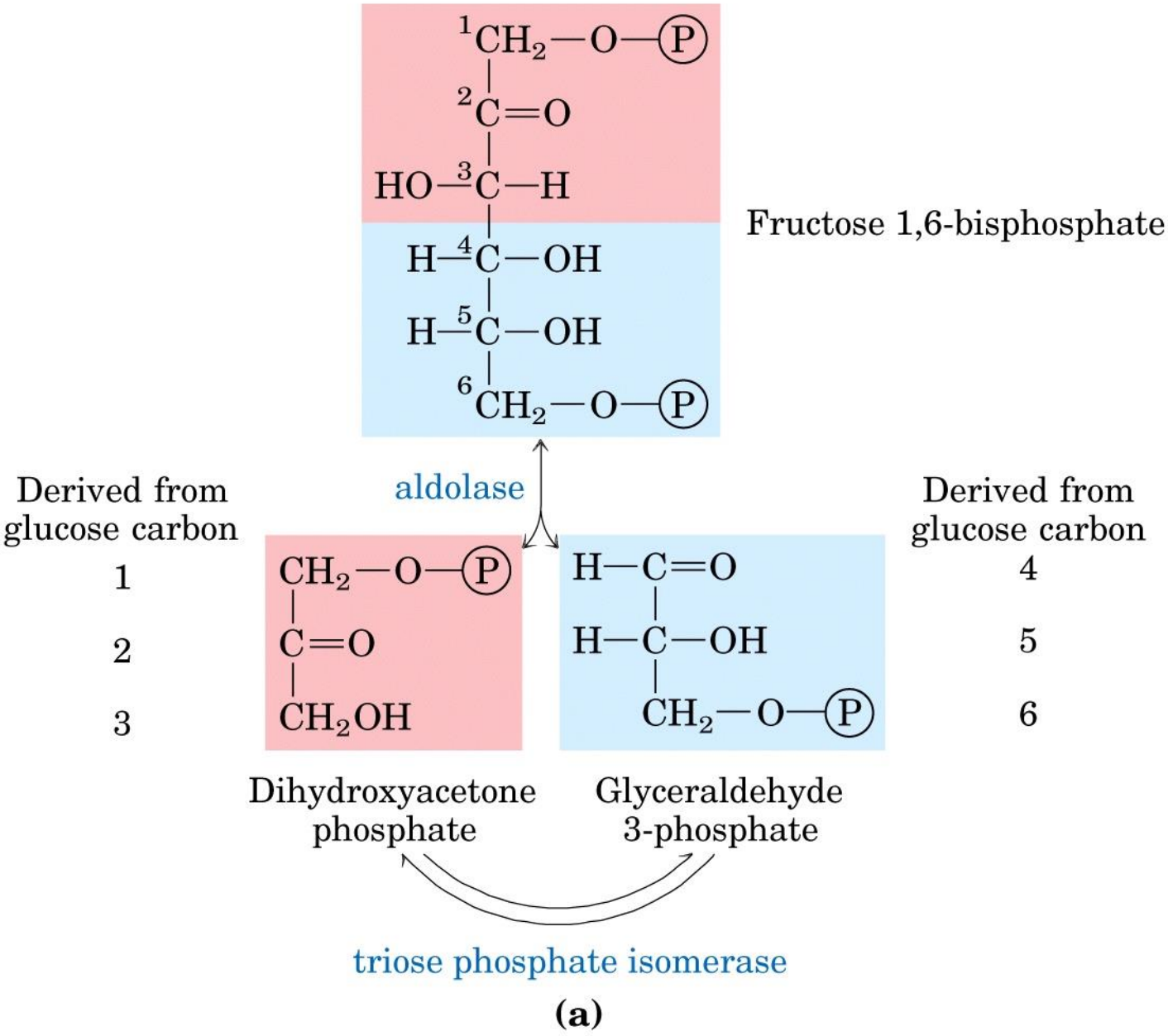
$\Delta G'^{\circ} = 23.8$ kJ/mol



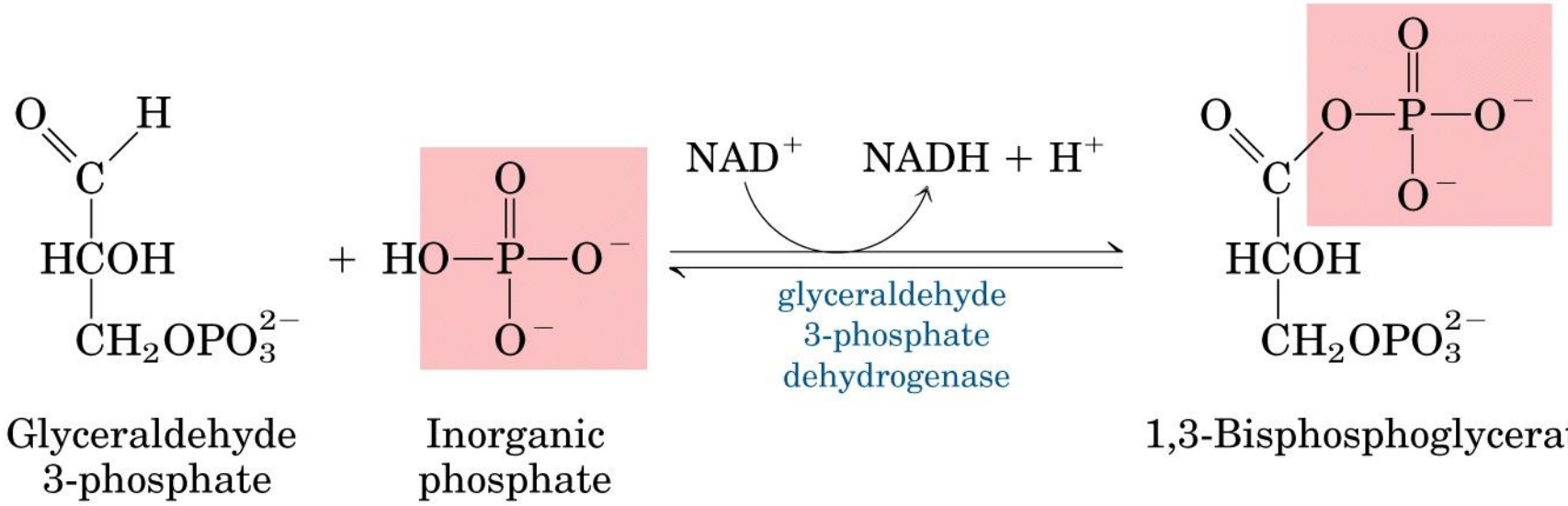
Dihydroxyacetone phosphate

Glyceraldehyde 3-phosphate

$\Delta G'^{\circ} = 7.5$ kJ/mol

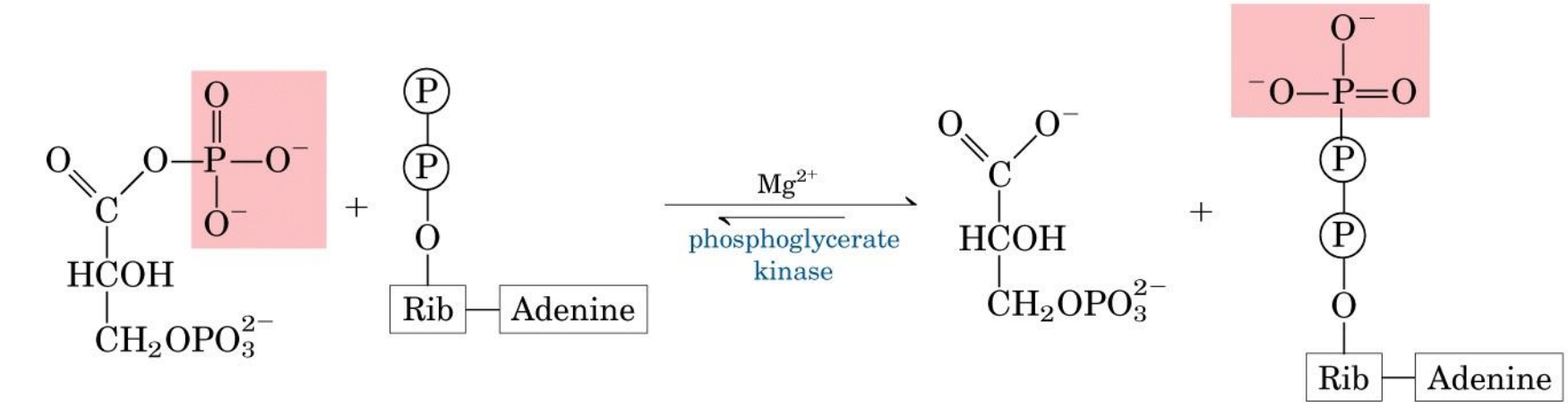

Fructose 1,6-bisphosphate
aldolase
Derived from glucose carbon
1
2
3
Derived from glucose carbon
4
5
6
Dihydroxyacetone phosphate
Glyceraldehyde 3-phosphate
triose phosphate isomerase

(a)



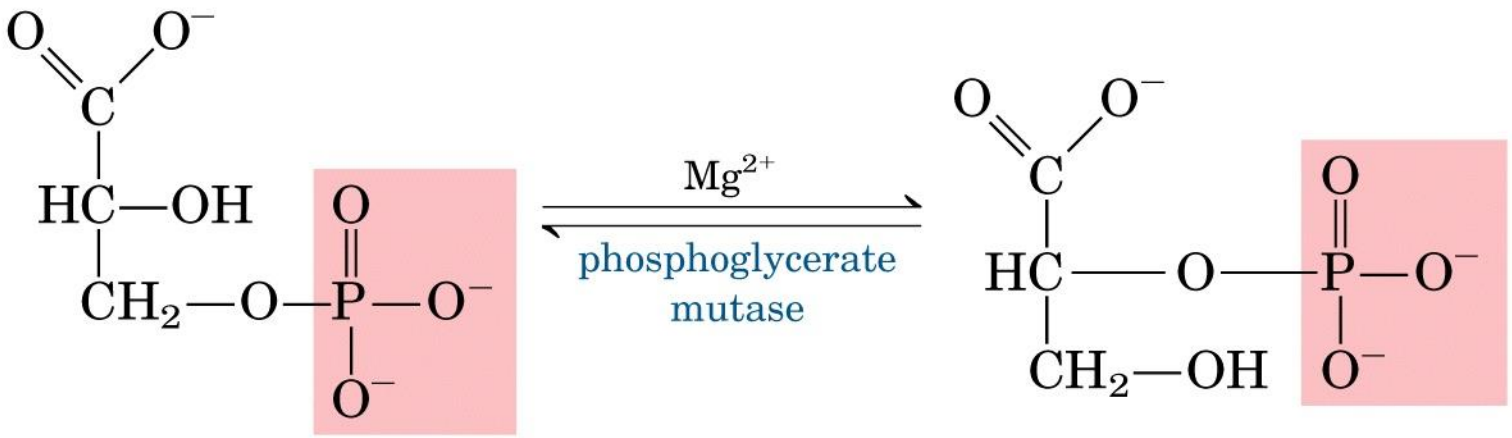
Glyceraldehyde 3-phosphate + Inorganic phosphate ⇌ 1,3-Bisphosphoglycerate

$\Delta G'^{\circ} = 6.3$ kJ/mol



1,3-Bisphosphoglycerate ADP 3-Phosphoglycerate ATP

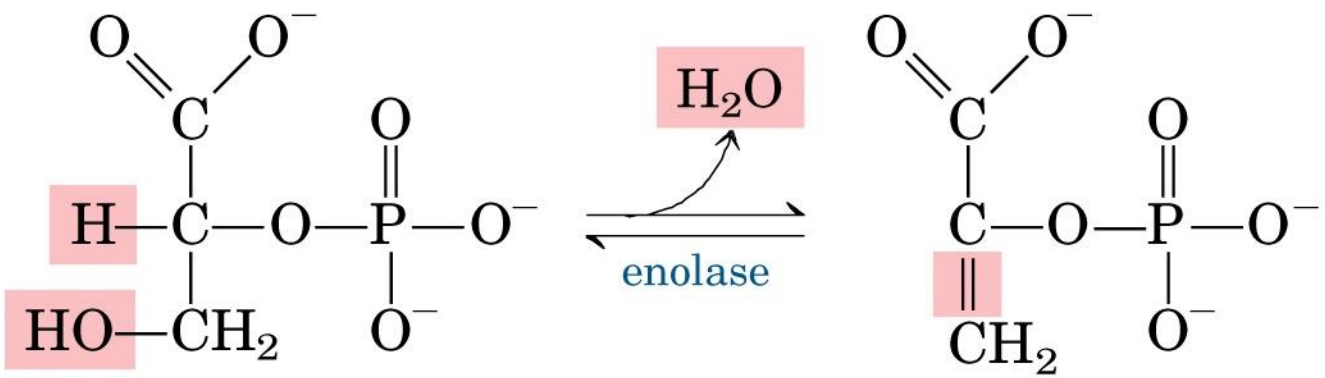
$\Delta G'^{\circ} = -18.5$ kJ/mol



3-Phosphoglycerate

2-Phosphoglycerate

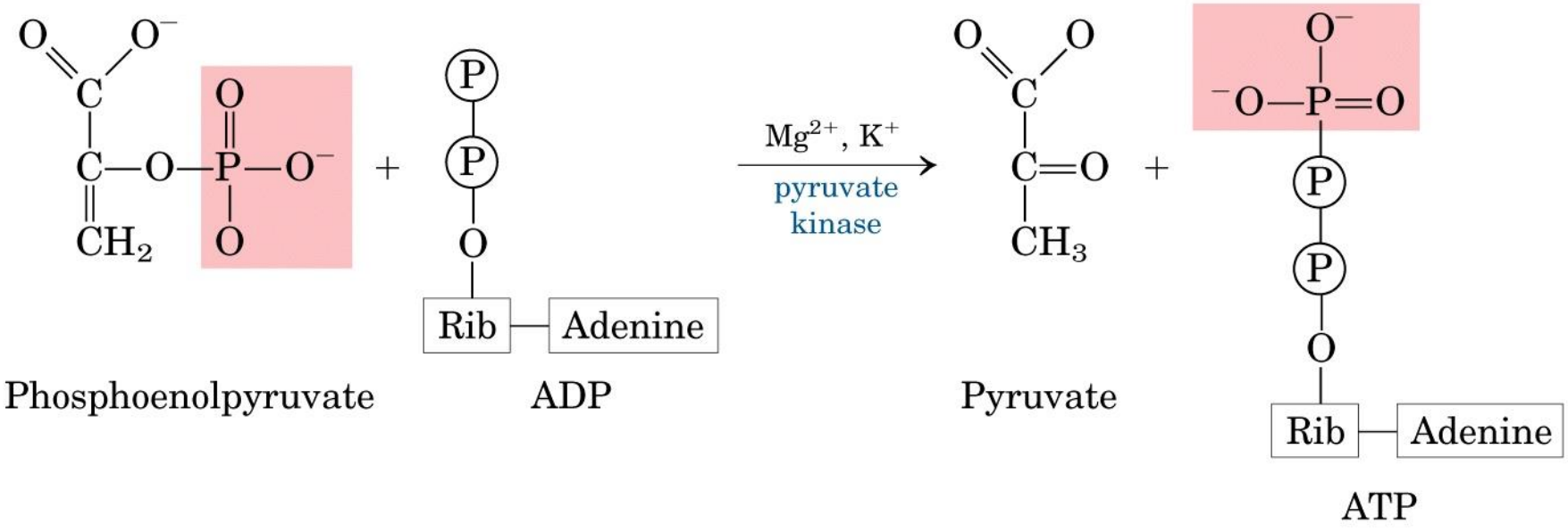
$\Delta G'^{\circ} = 4.4$ kJ/mol



2-Phosphoglycerate

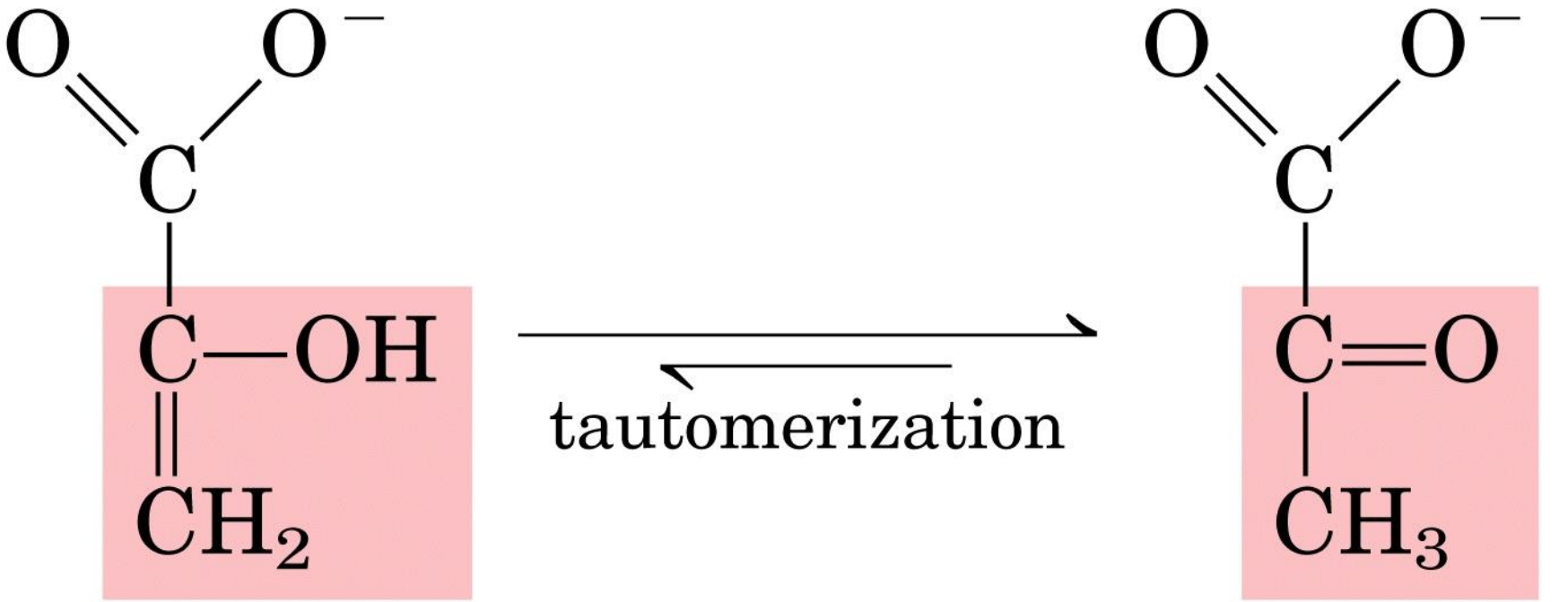
Phosphoenolpyruvate

$\Delta G'^{\circ} = 7.5$ kJ/mol



Phosphoenolpyruvate ADP Pyruvate ATP

$\Delta G'^{\circ} = -31.4$ kJ/mol



Pyruvate
(enol form)

Pyruvate
(keto form)

Reaction	Enzyme	$\Delta G^{\circ\prime}$ (kJ · mol^{-1})	ΔG (kJ · mol^{-1})
1	HK	−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	Negative
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).

Table 17-1 Standard Free Energy Changes ($\Delta G^{\circ\prime}$), and Physiological Free Energy Changes (ΔG) in Heart Muscle, of the Reactions of Glycolysis[a].

Reacción global de la vía Glucolítica

$$\text{Glucosa} + 2\text{ADP} + 2\text{P}_i + 2\text{NAD}^+ \longrightarrow 2\text{Piruvato} + 2\text{ATP} + 2\text{NADH} + 4\text{H}^+ + 2\text{H}_2\text{O}$$

DESTINOS DEL PIRUVATO

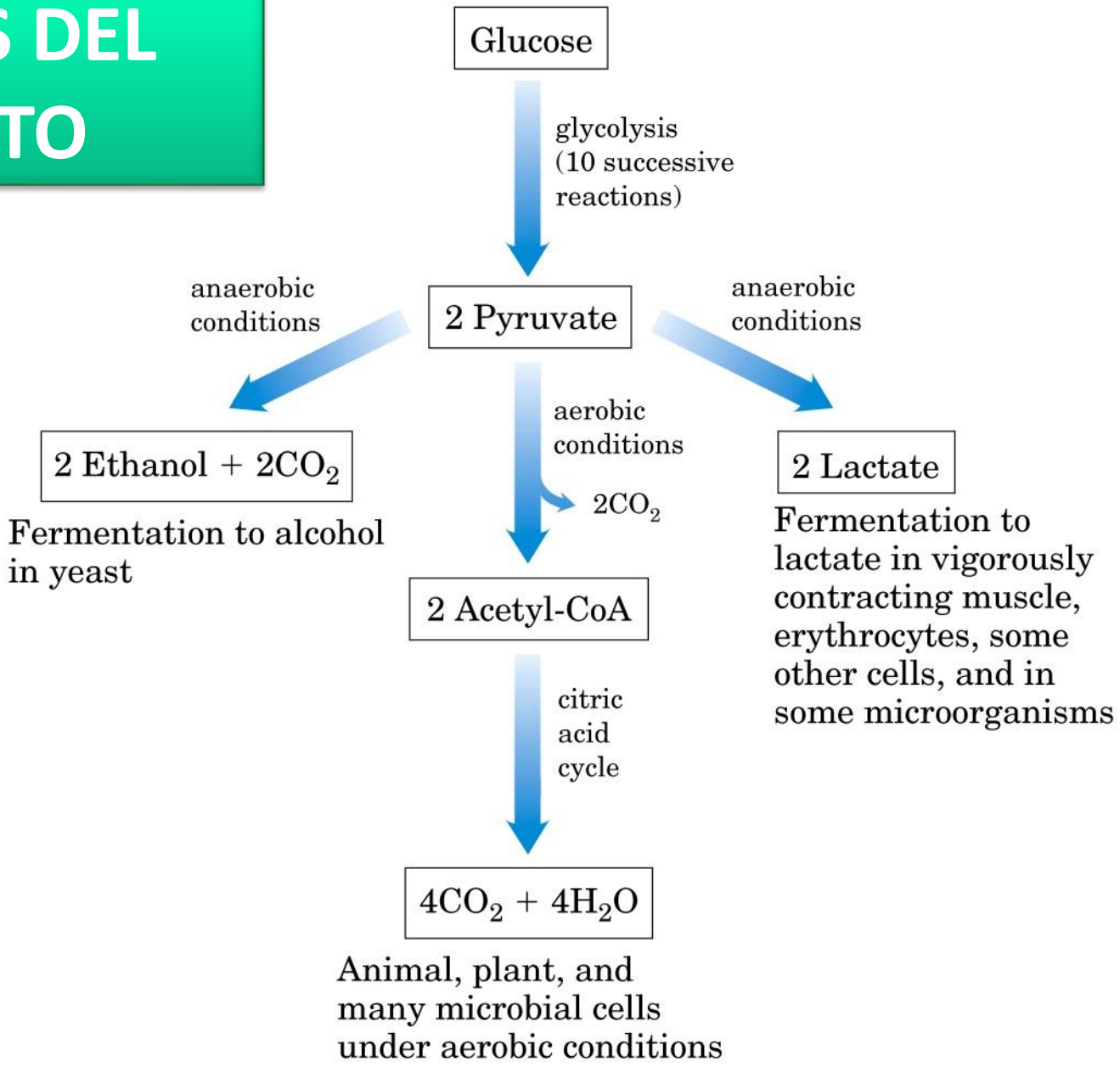


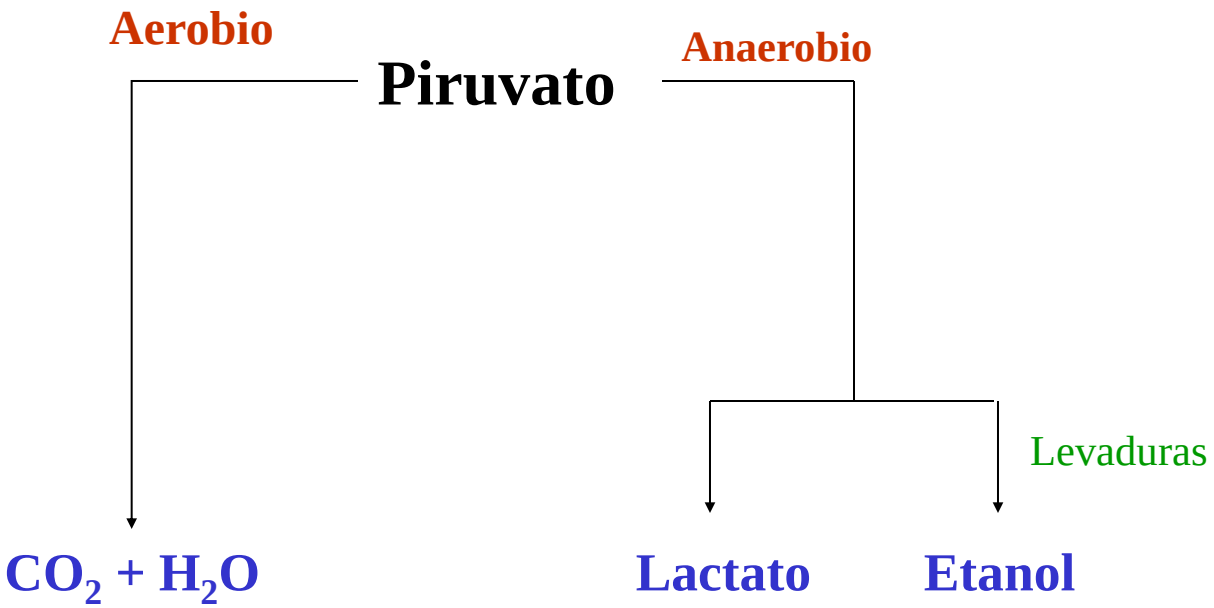
table 16–1

Stoichiometry of Coenzyme Reduction and ATP Formation in the Aerobic Oxidation of Glucose via Glycolysis, the Pyruvate Dehydrogenase Reaction, the Citric Acid Cycle, and Oxidative Phosphorylation

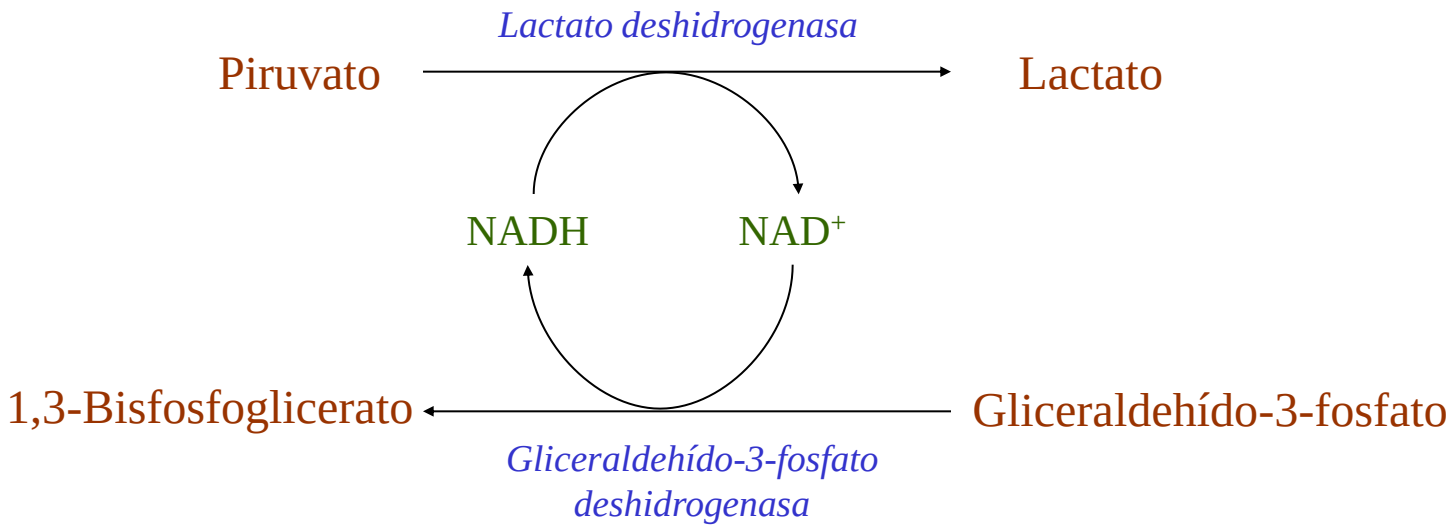
Reaction	Number of ATP or reduced coenzymes directly formed	Number of ATP ultimately formed*
Glucose ⟶ glucose 6-phosphate	−1 ATP	−1
Fructose 6-phosphate ⟶ fructose 1,6-bisphosphate	−1 ATP	−1
2 Glyceraldehyde 3-phosphate ⟶ 2 1,3-bisphosphoglycerate	2 NADH	3–5
2 1,3-Bisphosphoglycerate ⟶ 2 3-phosphoglycerate	2 ATP	2
2 Phosphoenolpyruvate ⟶ 2 pyruvate	2 ATP	2
2 Pyruvate ⟶ 2 acetyl-CoA	2 NADH	5
2 Isocitrate ⟶ 2 α-ketoglutarate	2 NADH	5
2 α-Ketoglutarate ⟶ 2 succinyl-CoA	2 NADH	5
2 Succinyl-CoA ⟶ 2 succinate	2 ATP (or 2 GTP)	2
2 Succinate ⟶ 2 fumarate	2 $FADH_2$	3
2 Malate ⟶ 2 oxaloacetate	2 NADH	5
Total		30–32

*This is calculated as 2.5 ATP per NADH and 1.5 ATP per $FADH_2$. A negative value indicates consumption.

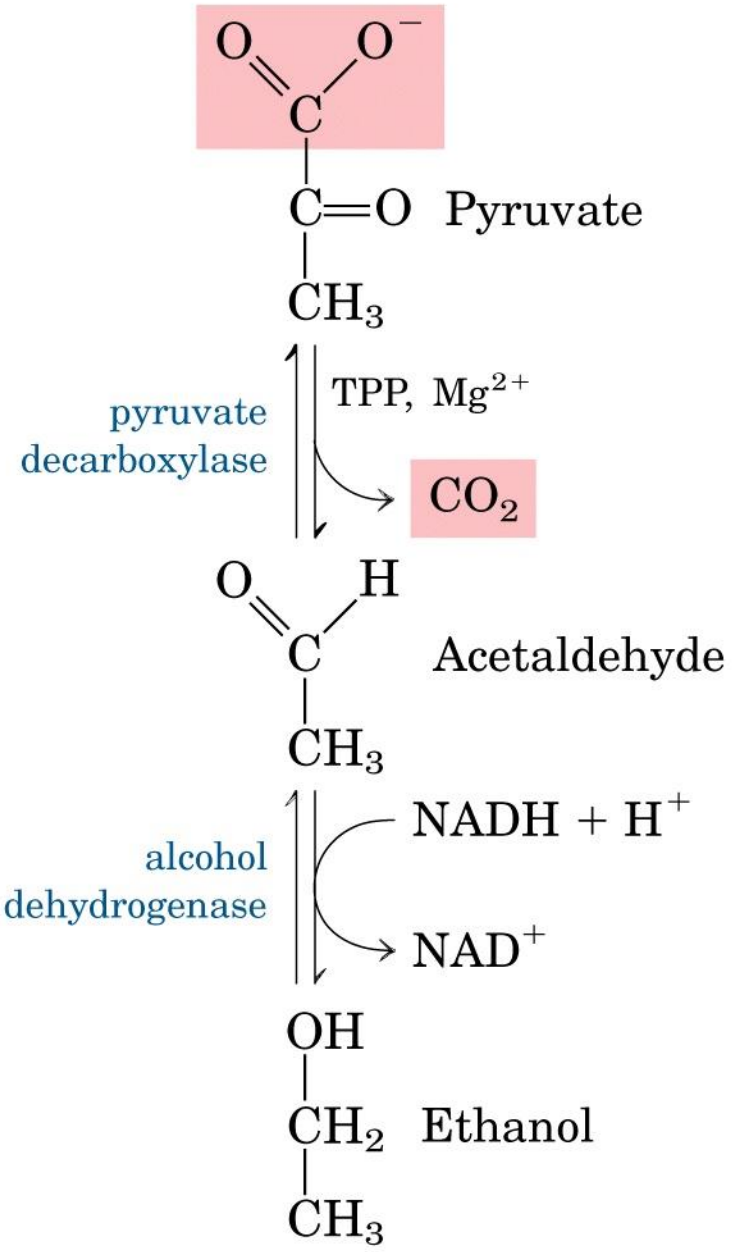
DESTINOS DEL PIRUVATO



DESTINO ANAEROBIO DEL PIRUVATO: FERMENTACIÓN LÁCTICA



DESTINO ANAEROBIO DEL PIRUVATO: FERMENTACIÓN ALCOHÓLICA



Balance energético de la vía Glucolítica

Aerobiosis

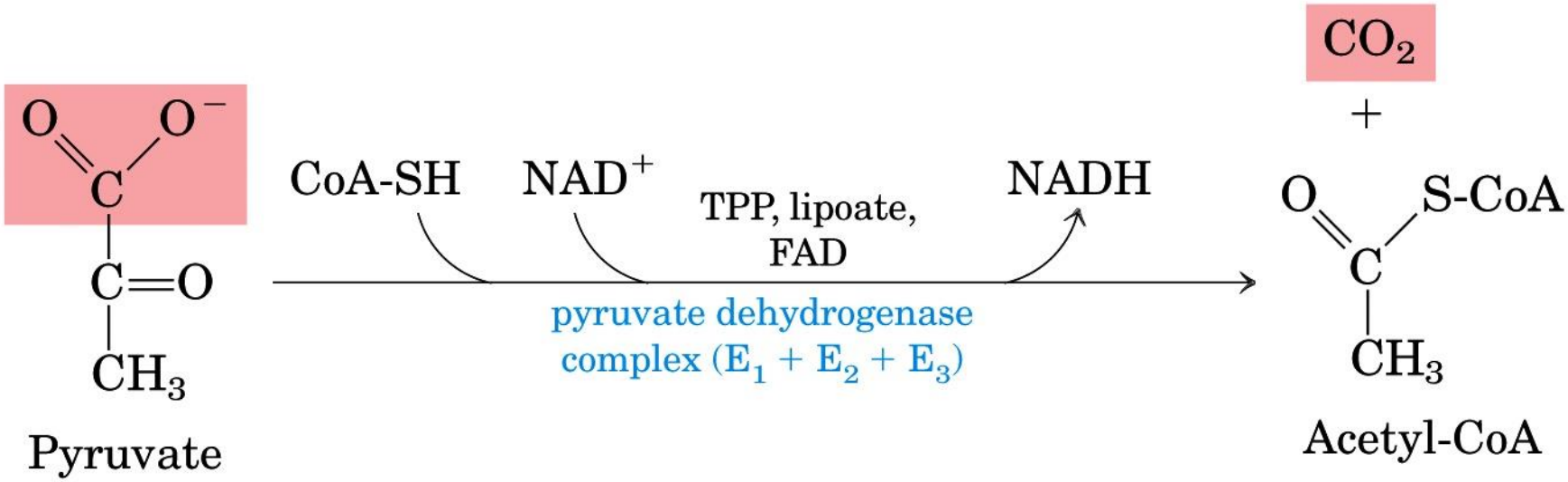
$$\text{Glucosa} + 32\,ADP + 32\,P_i + 6\,O_2 \longrightarrow 6\,CO_2 + 32\,ATP + 44\,H_2O$$

Anaerobiosis

$$\text{Glucosa} + 2\,ADP + 2\,P_i \longrightarrow 2\,\text{lactato} + 2\,ATP + 2\,H_2O \quad \Delta G^{o'} = -135\ KJ/mol$$

$$\text{Glucosa} + 2ADP + 2P_i \longrightarrow 2\text{etanol} + 2CO_2 + 2ATP + 2H_2O$$

DESTINO AERÓBICO DEL PIRUVATO: DESCARBOXILACIÓN OXIDATIVA



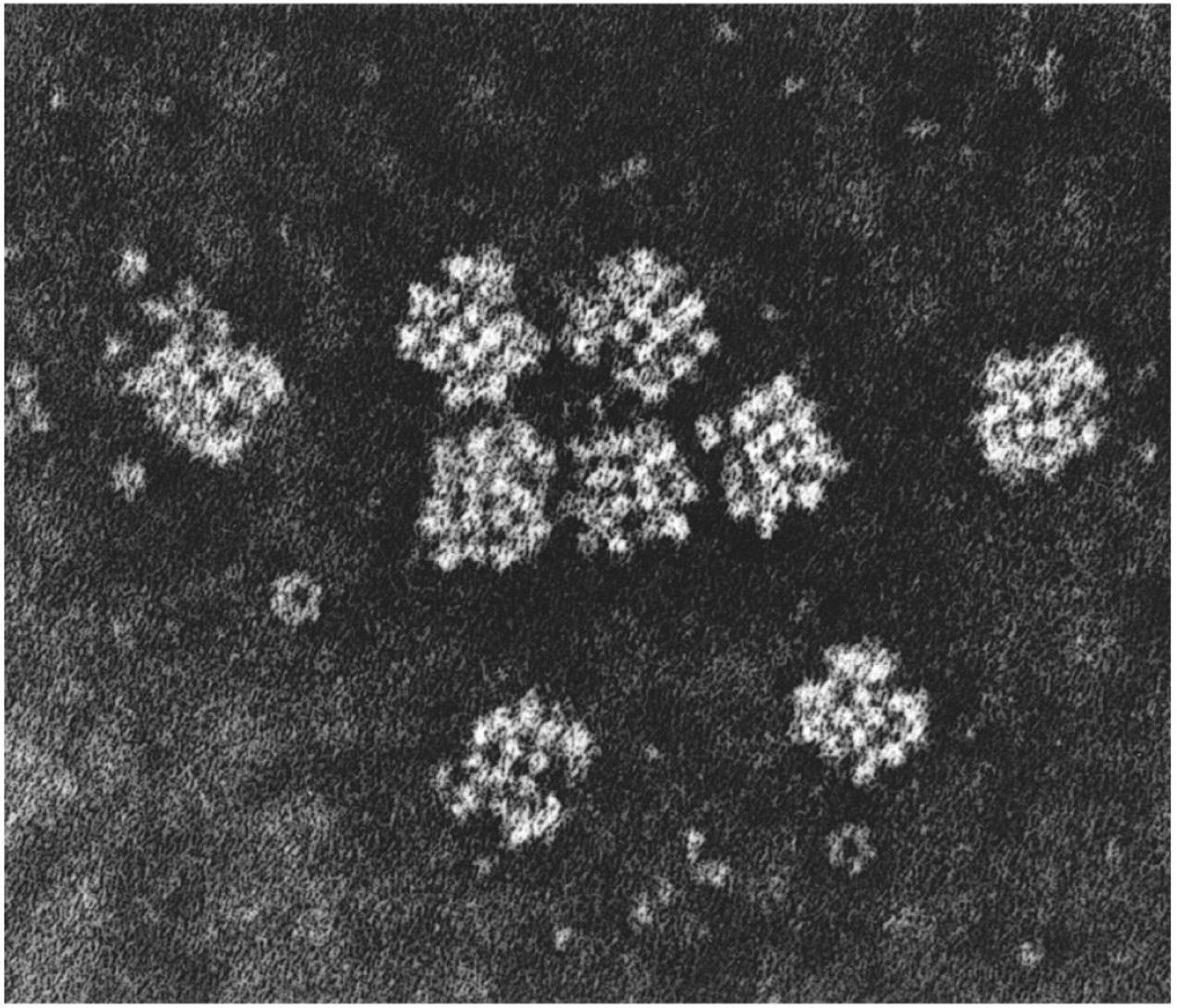
$\Delta G'^{\circ} = -33.4$ kJ/mol

Complejo Piruvato deshidrogenasa de *E.coli*

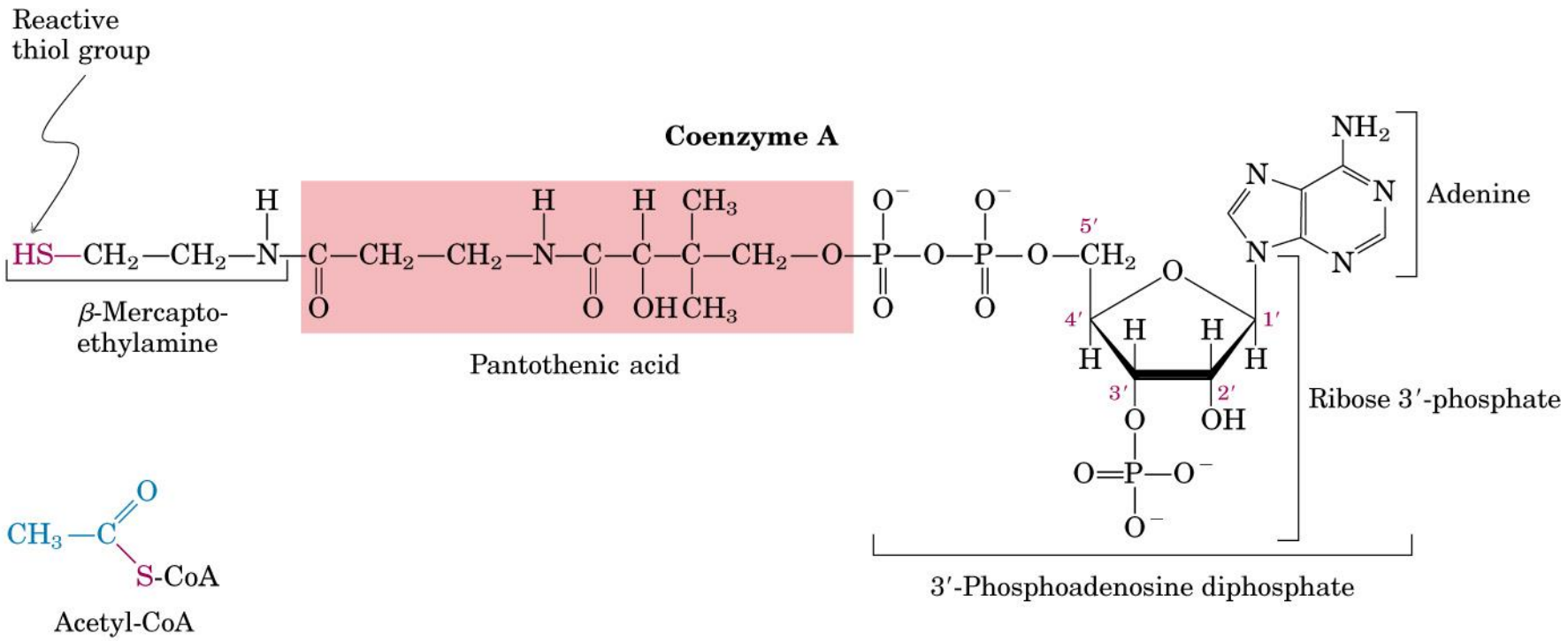
E1. piruvato deshidrogenasa. 24 copias, contiene unido TPP

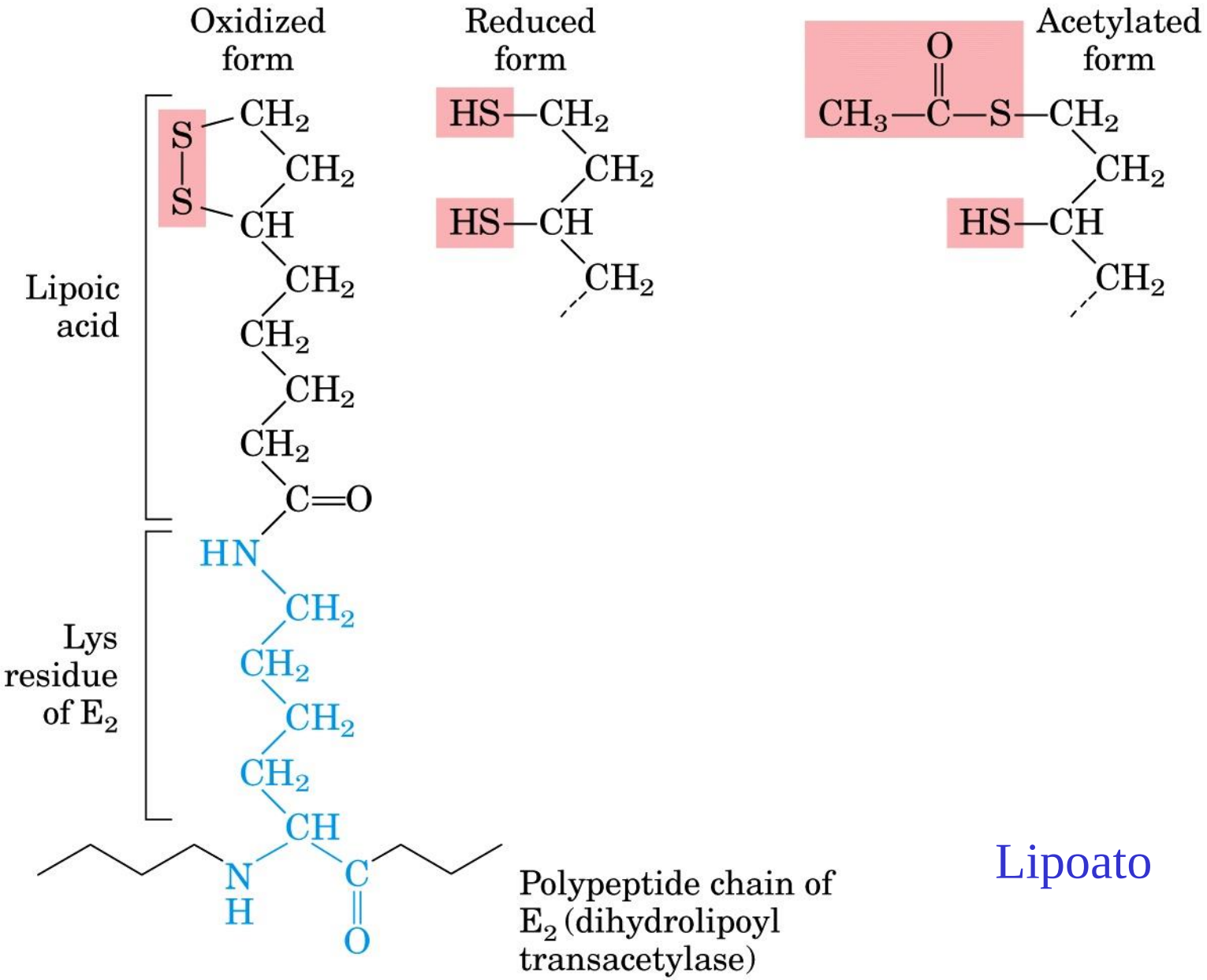
E2. dihidrolipoil transcetilasa. 24 copias, cada una con 3 moléculas de lipoato

E3. dihidrolipoil deshidrogenasa. 12 copias, contiene unido FAD

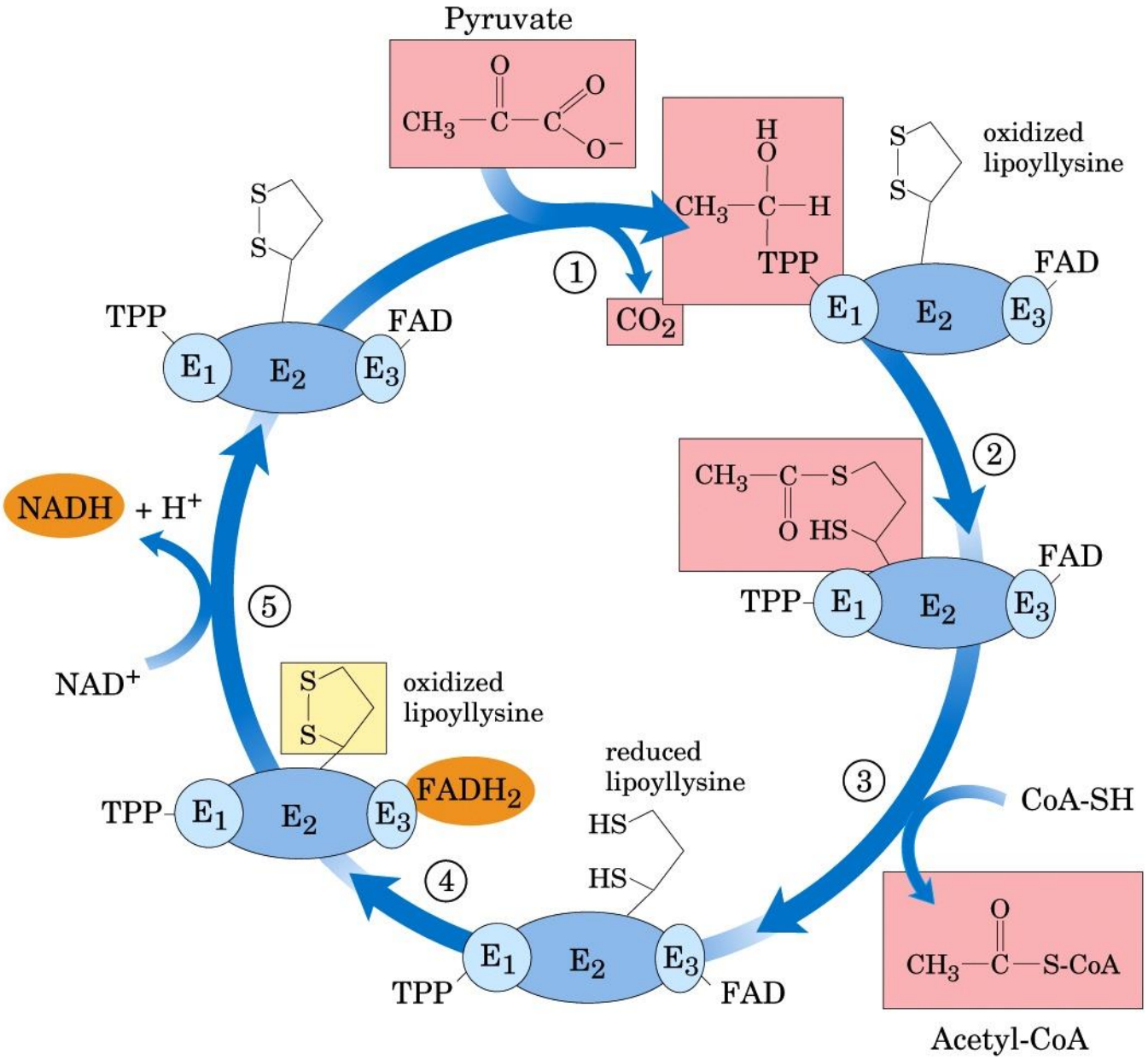

0.05 μm

Coenzima A

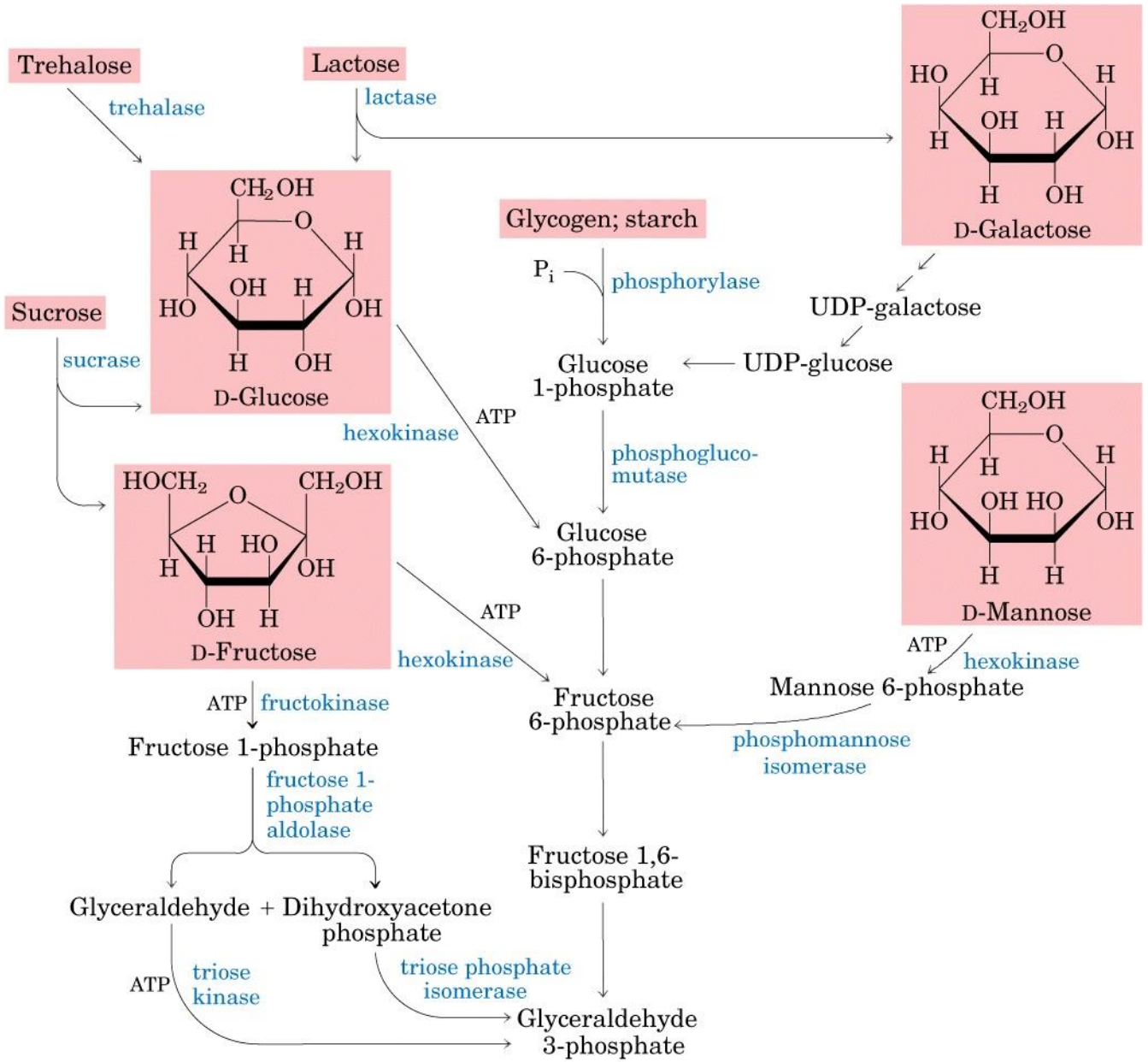

Reactive thiol group
Coenzyme A
β-Mercapto-ethylamine
Pantothenic acid
Adenine
Ribose 3′-phosphate
3′-Phosphoadenosine diphosphate
Acetyl-CoA
S-CoA

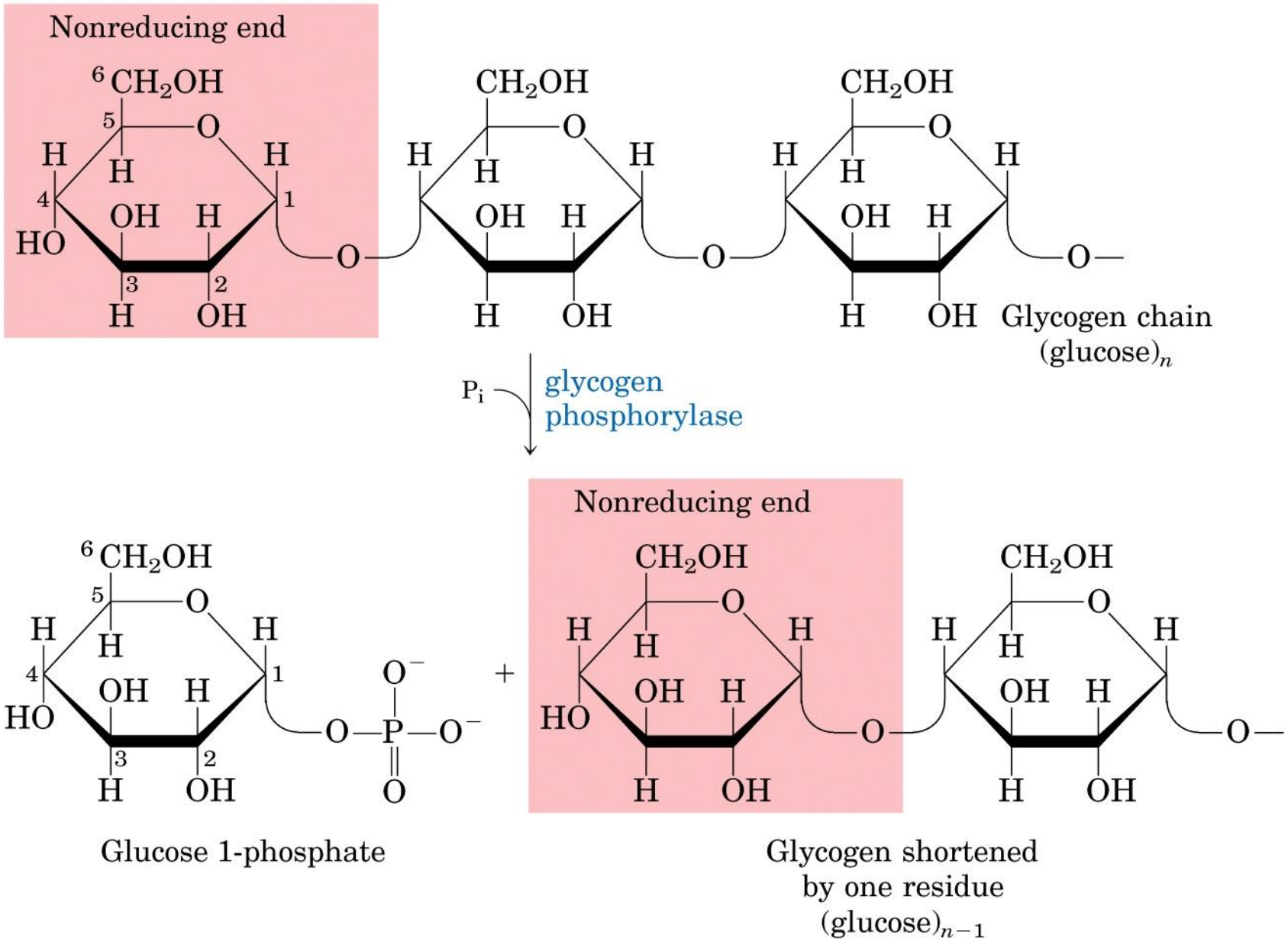

Oxidized form
Reduced form
Acetylated form
Lipoic acid
Lys residue of E_2
Polypeptide chain of E_2 (dihydrolipoyl transacetylase)

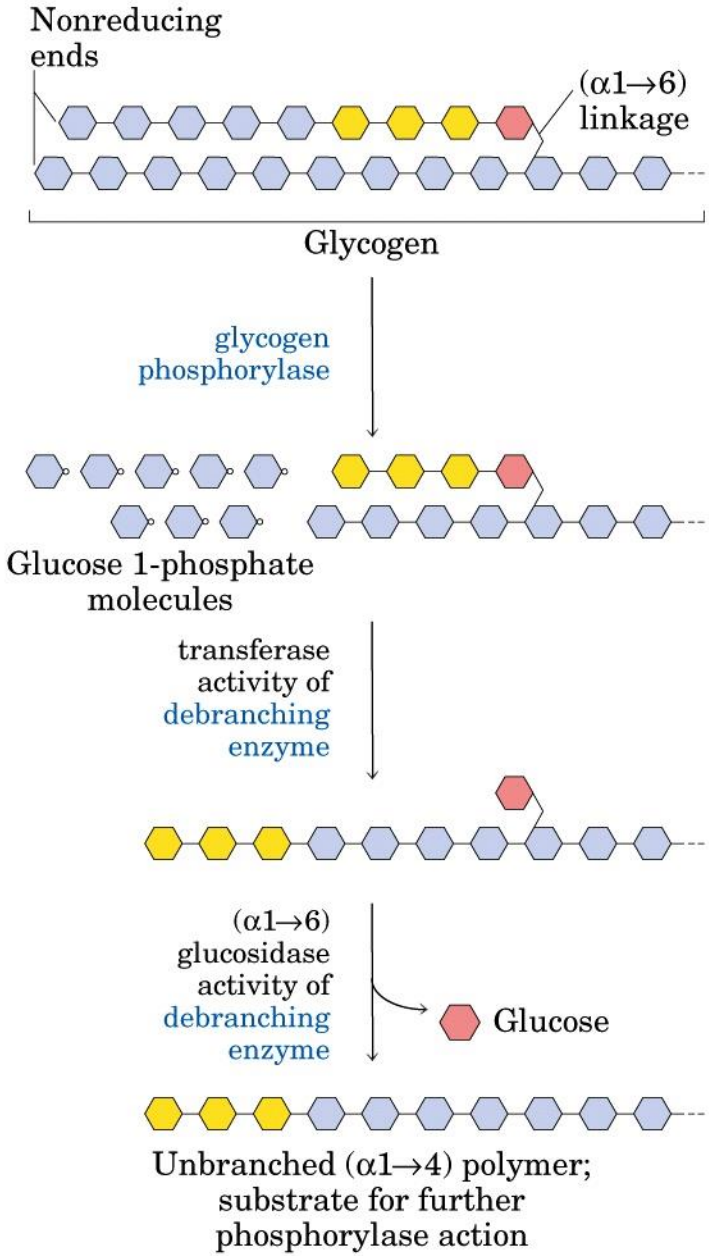
Lipoato


Pyruvate
$CH_3-C(=O)-C(=O)-O^-$
1
CO_2
$CH_3-C(H)(OH)-TPP$
oxidized lipoyllysine
FAD
TPP
E_1 E_2 E_3
2
$CH_3-C(=O)-S-HS$
3
CoA-SH
$CH_3-C(=O)-S-CoA$
Acetyl-CoA
reduced lipoyllysine
HS HS
4
$FADH_2$
oxidized lipoyllysine
5
NADH + H^+
NAD^+

RUTAS ALIMENTADORAS DE LA GLUCOLISIS




Nonreducing end
Glycogen chain
(glucose)$_n$
P_i
glycogen
phosphorylase
Nonreducing end
Glucose 1-phosphate
Glycogen shortened
by one residue
(glucose)$_{n-1}$


Nonreducing ends
(α1→6) linkage
Glycogen
glycogen phosphorylase
Glucose 1-phosphate molecules
transferase activity of debranching enzyme
(α1→6) glucosidase activity of debranching enzyme
Glucose
Unbranched (α1→4) polymer; substrate for further phosphorylase action

DISACÁRIDOS DE LA DIETA

Dextrina + nH_2O $\xrightarrow{\text{dextrinasa}}$ n D-glucosa

Maltosa + H_2O $\xrightarrow{\text{maltasa}}$ 2 D-glucosa

Lactosa + H_2O $\xrightarrow{\text{lactasa}}$ D-galactosa + D-glucosa

Sacarosa + H_2O $\xrightarrow{\text{sacarasa}}$ D-fructosa + D-glucosa

Trehalosa + H_2O $\xrightarrow{\text{trehalasa}}$ 2 D-glucosa

RUTA DE LAS PENTOSAS FOSFATO

- Proveedor de NADPH para la biosíntesis
- Productora de Ribosa 5 fosfato
- Consta de 2 procesos oxidativos seguidos de 5 etapas no oxidativos
- Tiene lugar mayormente en citoplasma de hepatocitos y adipocitos
- El NADPH es usado para la biosíntesis de ácidos grasos que ocurre en el citoplasma

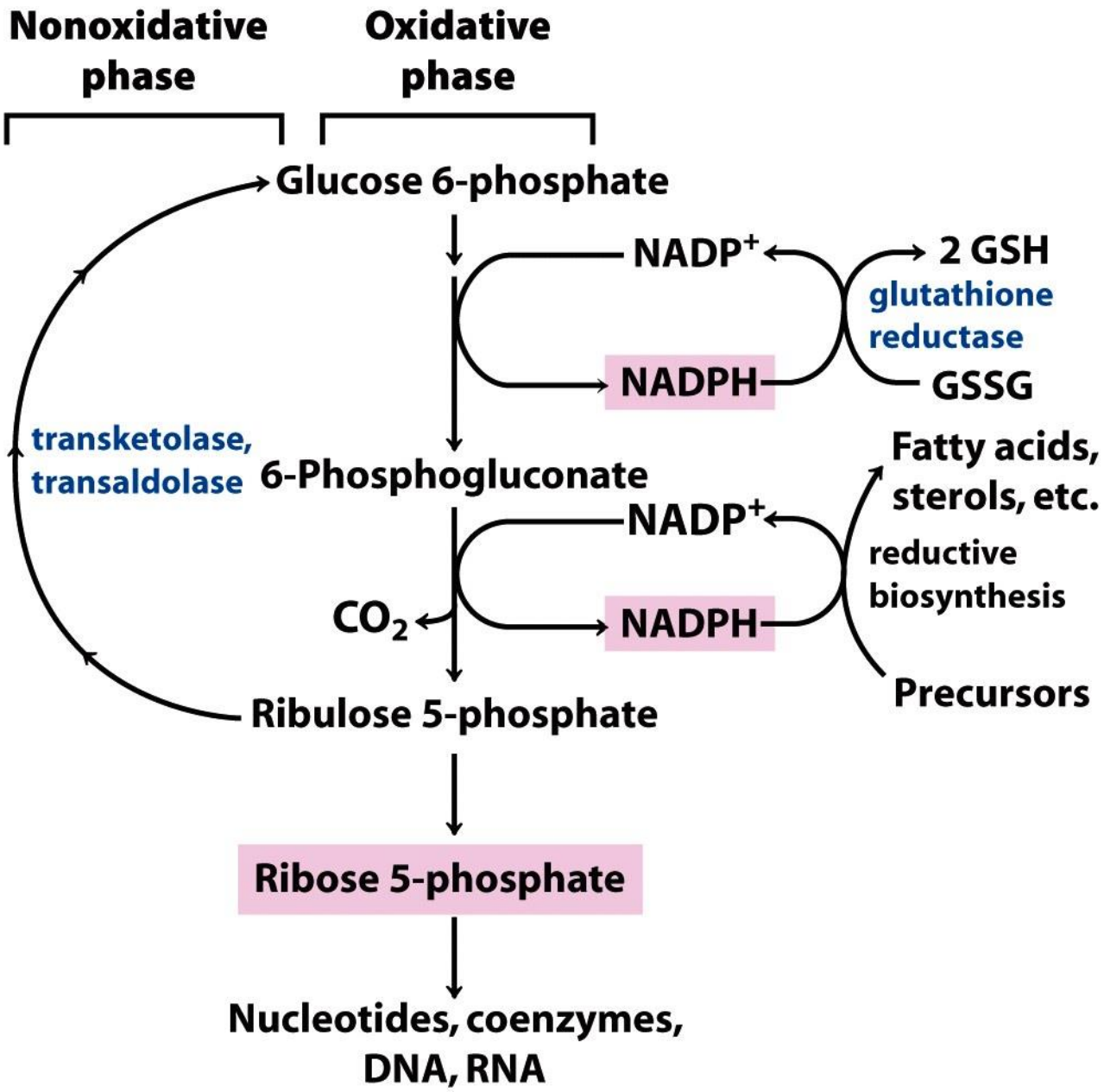


Figure 14-20
Lehninger Principles of Biochemistry, Fifth Edition

Etapa no oxidativa

4 tipos de reacción

- Fosfopentosa isomerasa

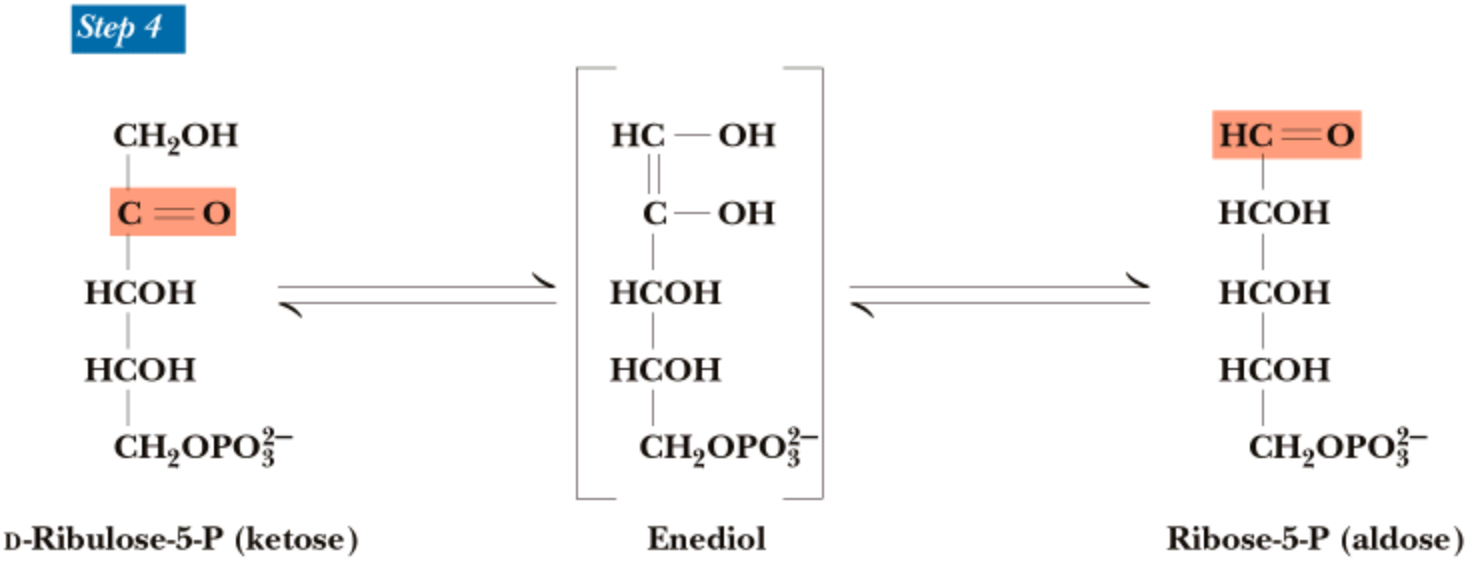
  convierte cetosa a aldosa
- Fosfopentosa Epimerasa

  epimeriza a C-3
- Transcetolasa (TPP-dependiente)

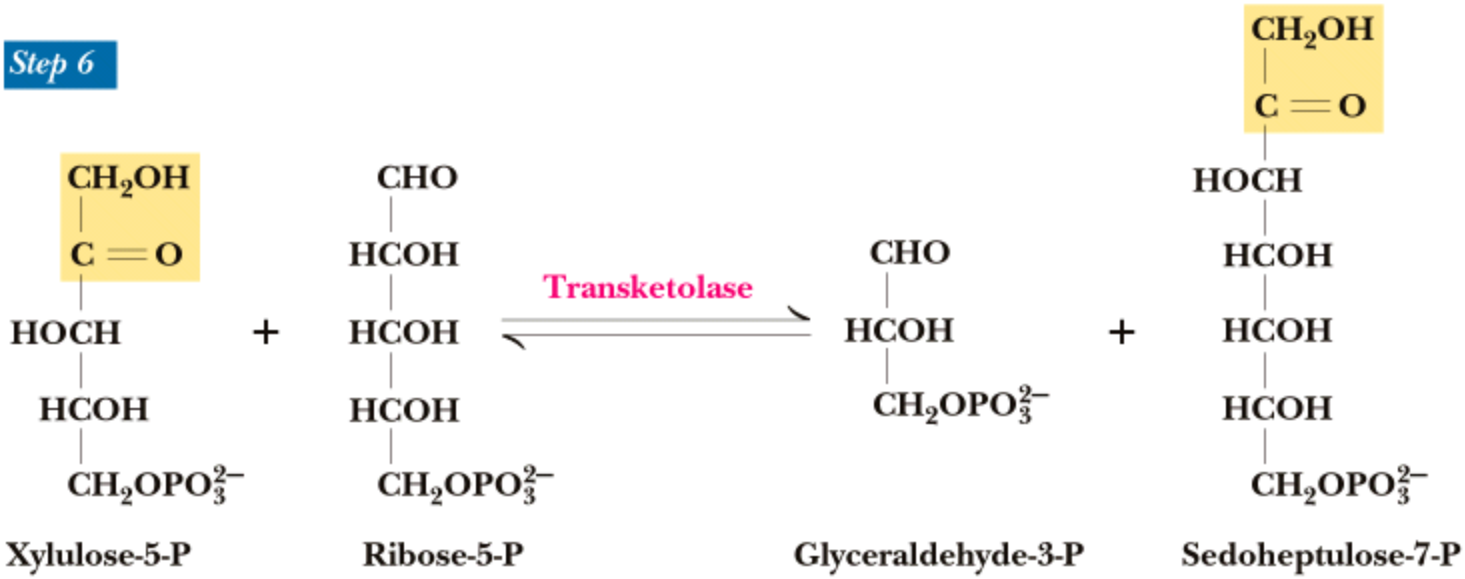
  transferencia de unidades de 2 átomos de carbono
- Transaldolasa

  transferencia de una unidad de 3 átomos de carbono

Garrett & Grisham: Biochemistry, 2/e
Figure 23.30

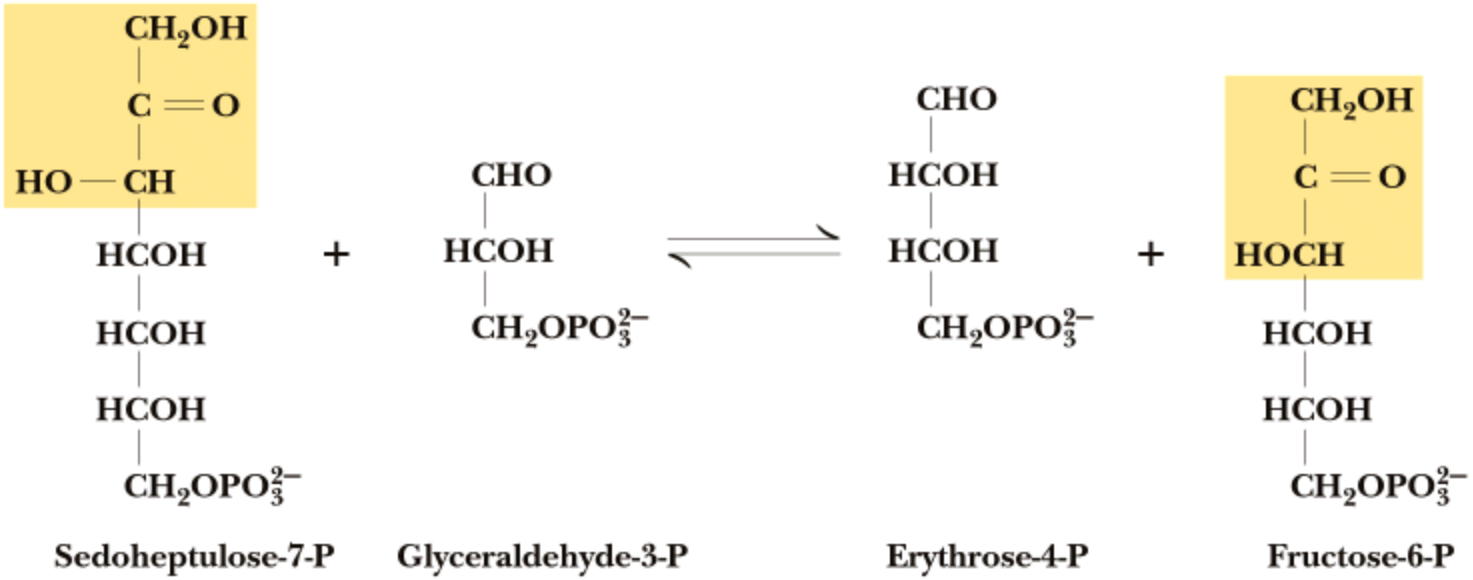


Garrett & Grisham: Biochemistry, 2/e
Figure 23.32



Garrett & Grisham: Biochemistry, 2/e
Figure 23.35

Step 7



Sedoheptulose-7-P Glyceraldehyde-3-P Erythrose-4-P Fructose-6-P

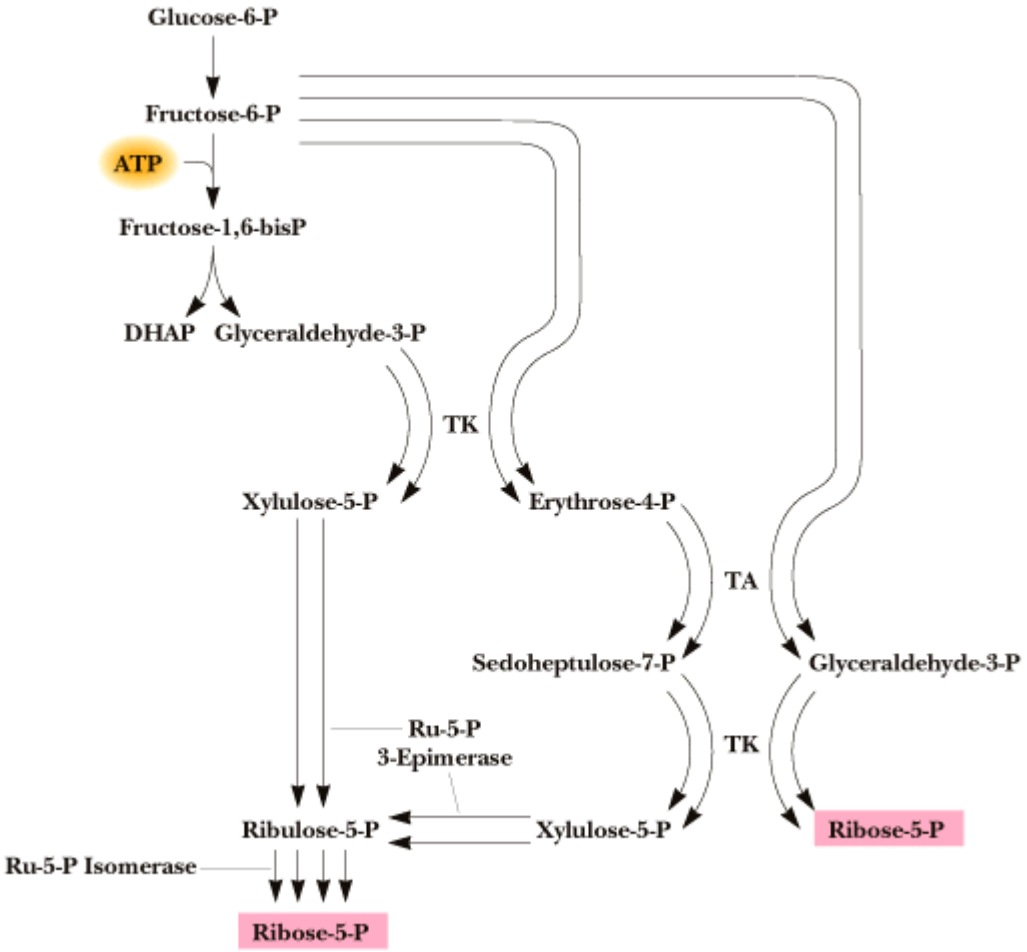
RUTA DE LAS PENTOSAS FOSFATO: VARIACIONES DE LA VÍA

Caso que se necesite tanto ribosa como NADPH

Saunders College Publishing

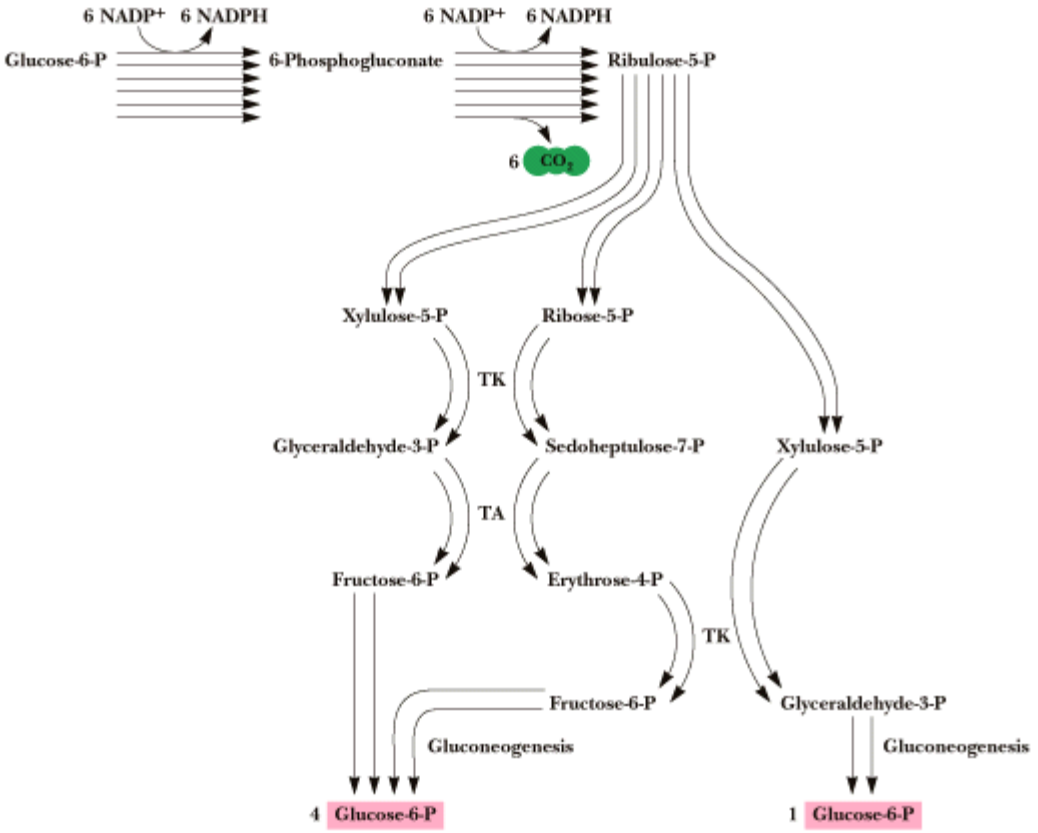
RUTA DE LAS PENTOSAS FOSFATO: VARIACIONES DE LA VÍA

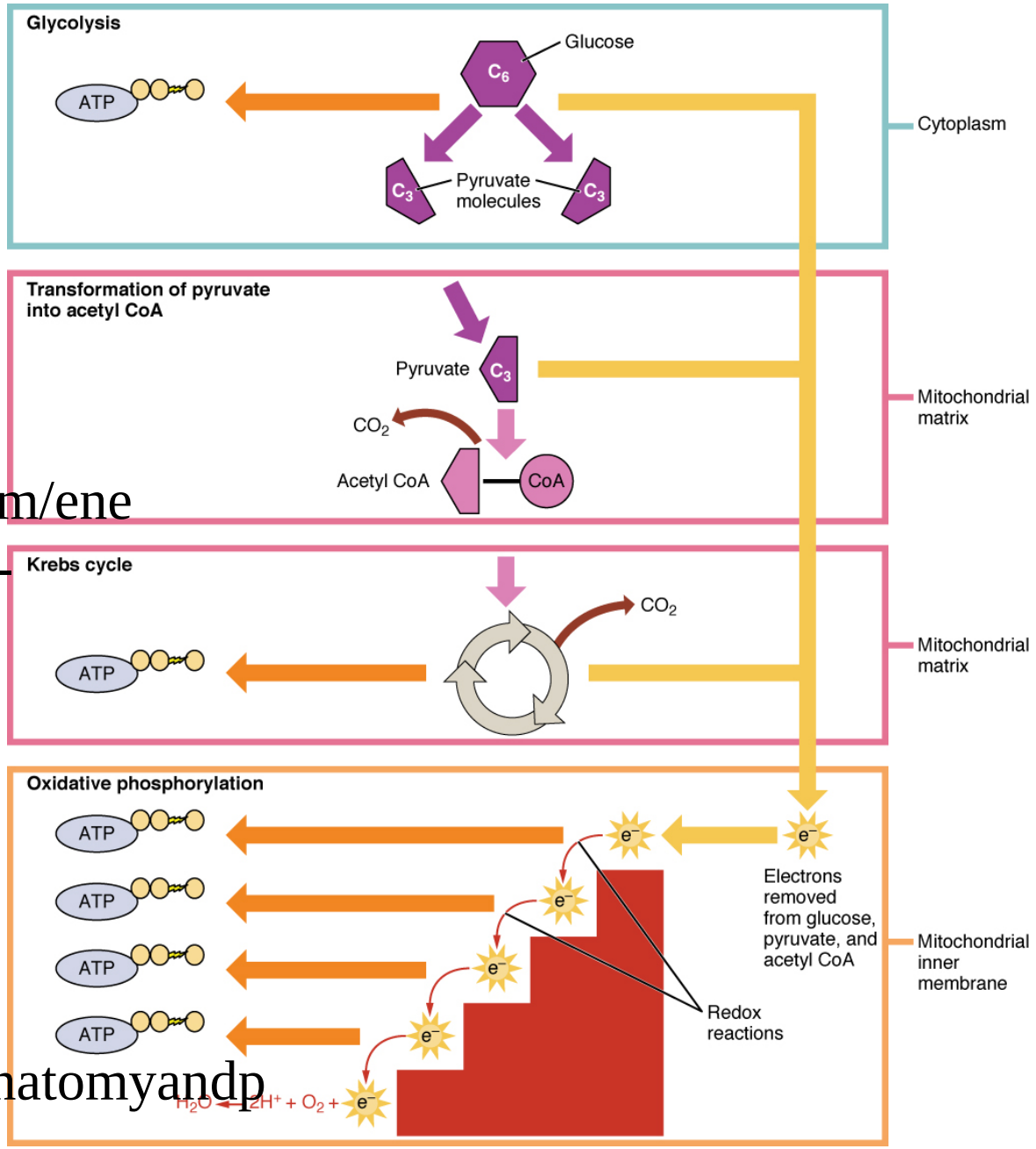
Caso que se necesite más ribosa que NADPH



RUTA DE LAS PENTOSAS FOSFATO: VARIACIONES DE LA VÍA

Caso que se necesite más NADPH que ribosa





ys.utorontoeit.com/ene
sm/carbohydrate-

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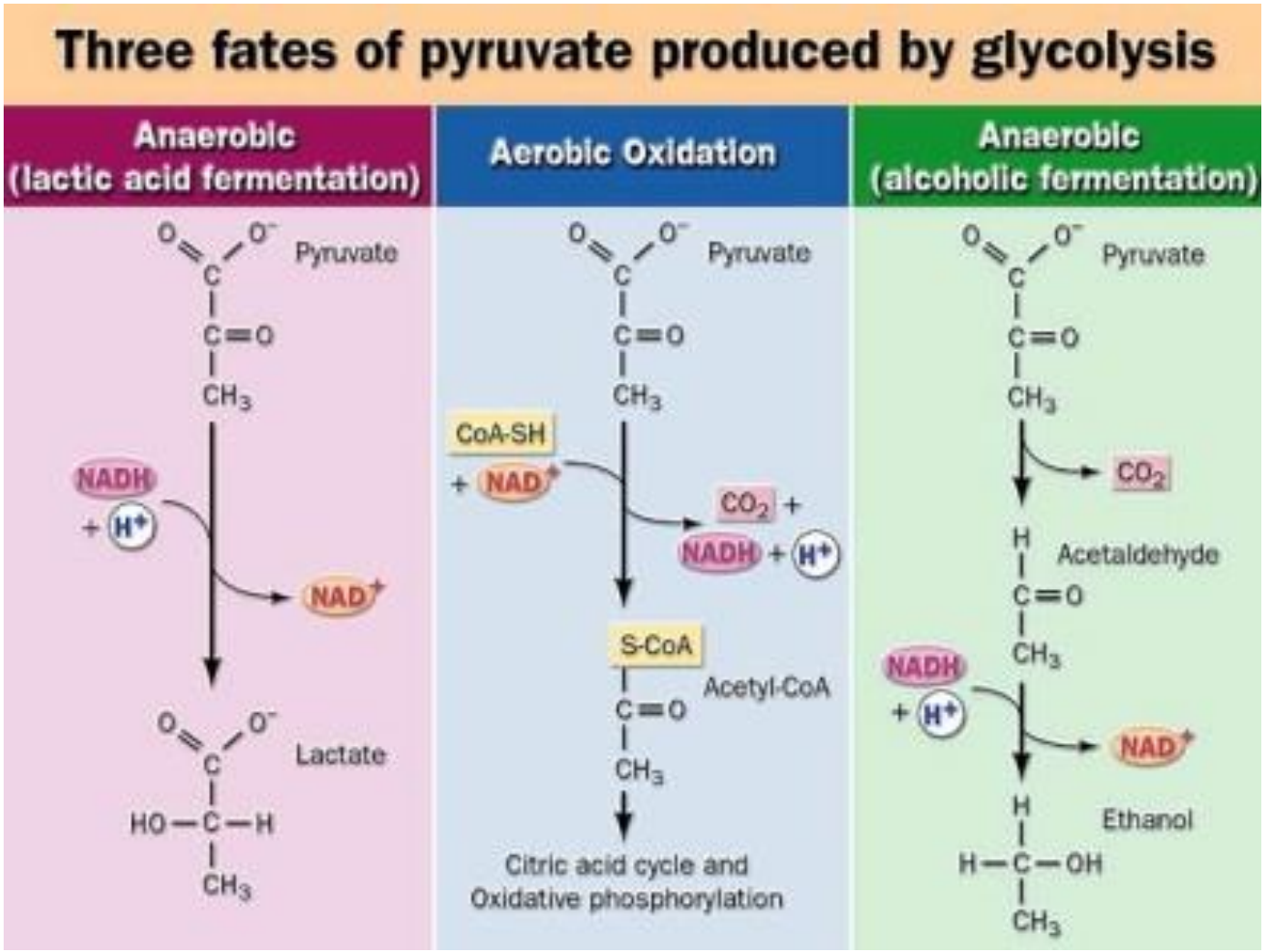
Three fates of pyruvate produced by glycolysis
Anaerobic (lactic acid fermentation)
Aerobic Oxidation
Anaerobic (alcoholic fermentation)
Pyruvate
NADH
+ H+
NAD+
Lactate
HO—C—H
CH3
CoA-SH
+ NAD+
CO2 +
NADH + H+
S-CoA
Acetyl-CoA
Citric acid cycle and
Oxidative phosphorylation
CO2
Acetaldehyde
Ethanol
H—C—OH

Summary of pathways