

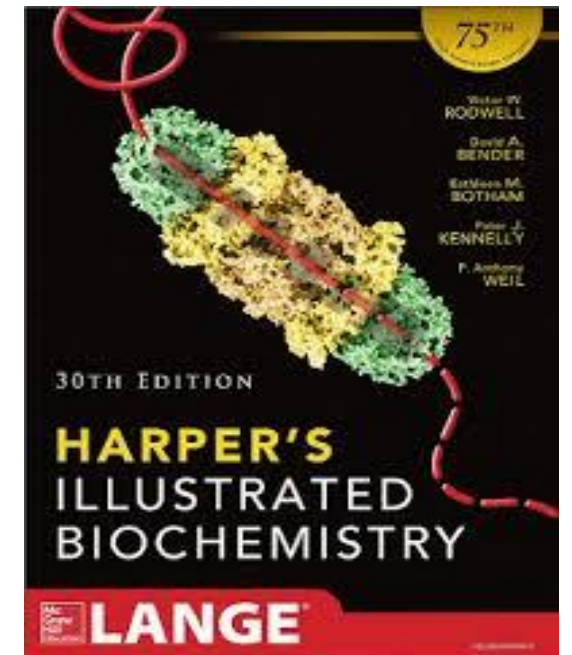
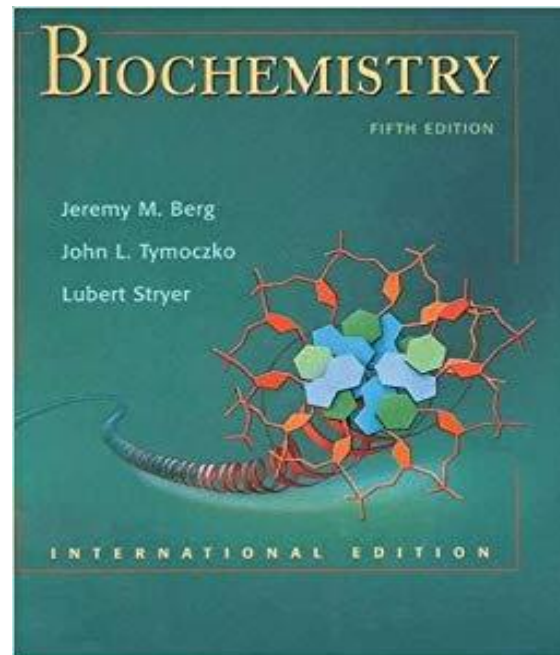
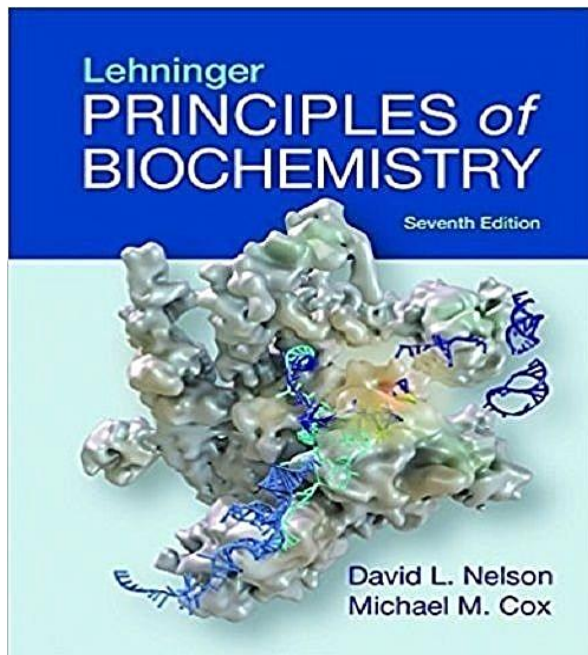
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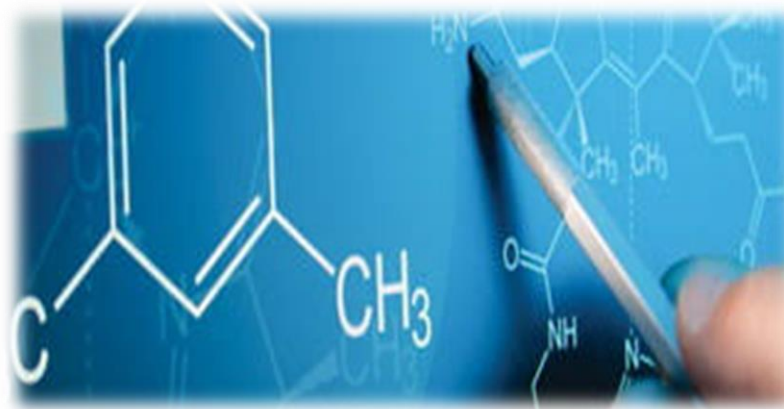


# بیوشیمی عمومی

دوره کارشناسی



تعریف و مقدمه ✓  
اهمیت علم بیوشیمی ✓  
ارتباط بیوشیمی و کشاورزی ✓



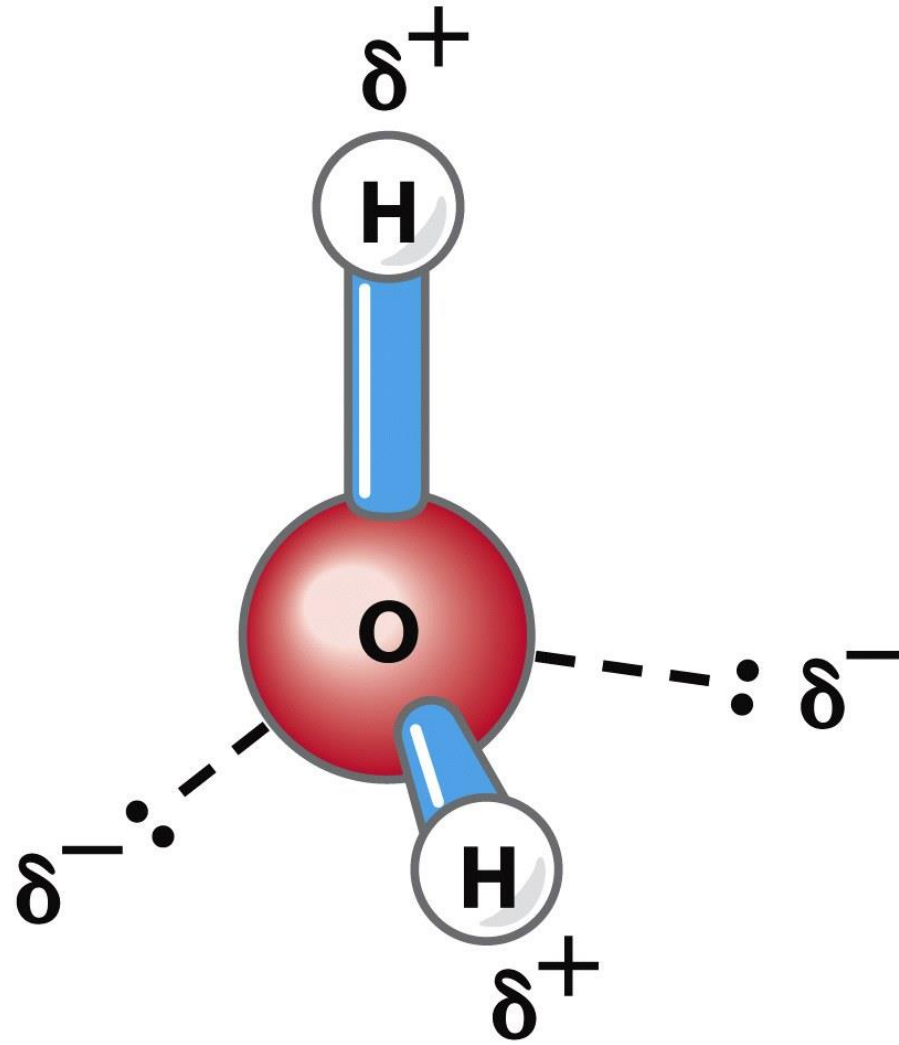


# آب ✓

- اهمیت
- ویژگی ها
- قطبیت و پیوند هیدروژنی

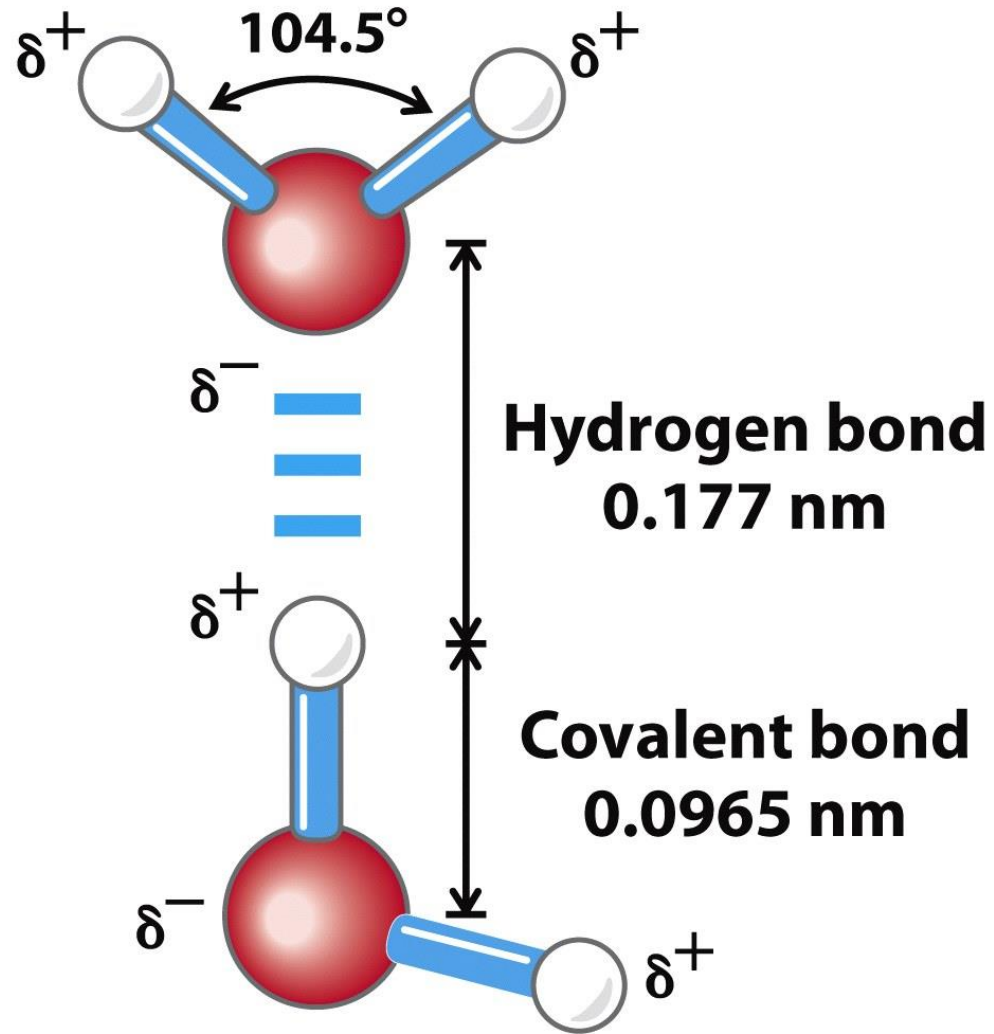


# Structure of Water



**Figure 2-1a**  
*Lehninger Principles of Biochemistry, Fifth Edition*  
© 2008 W. H. Freeman and Company

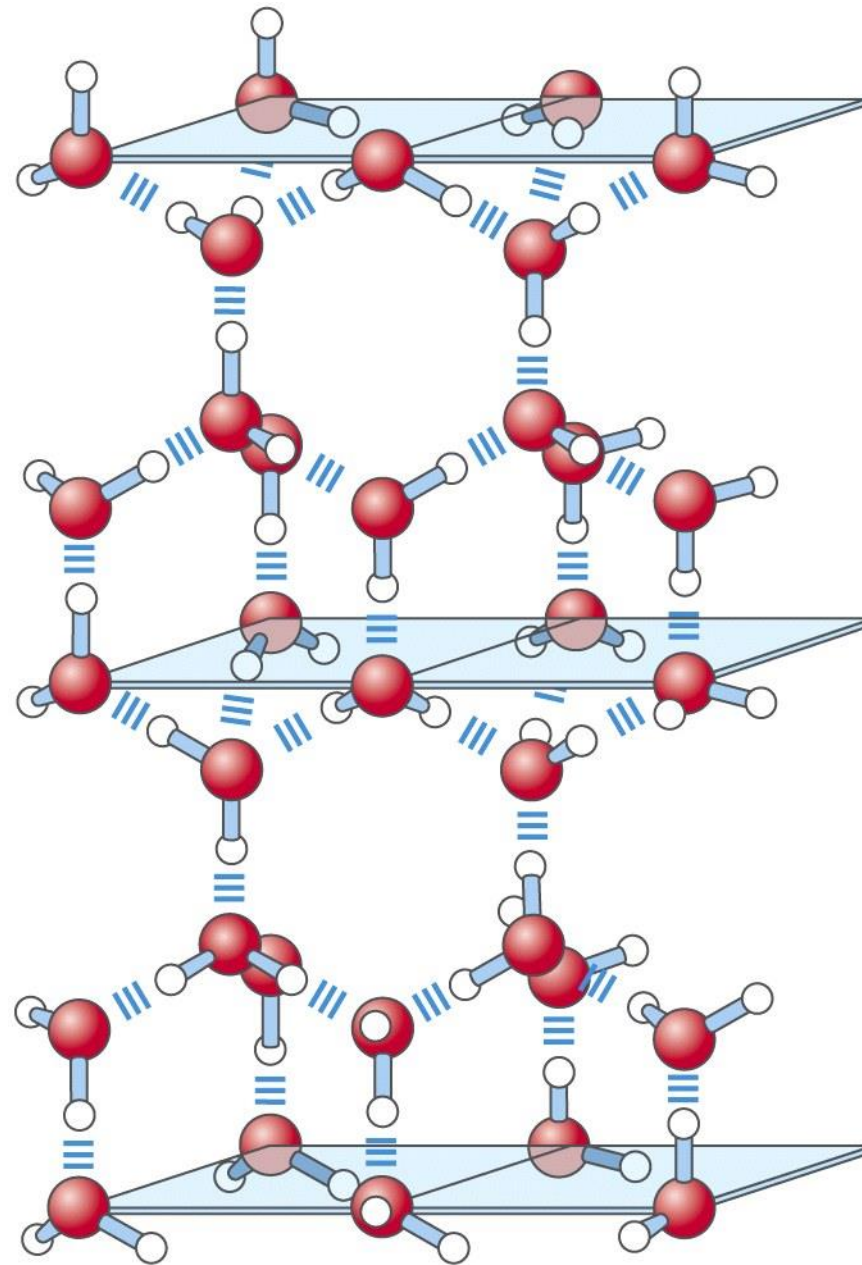
# Structure of Water



**Figure 2-1b**  
*Lehninger Principles of Biochemistry, Fifth Edition*  
© 2008 W. H. Freeman and Company



# Hydrogen bonds in water



**Figure 2-2**

*Lehninger Principles of Biochemistry, Fifth Edition*

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# آب ✓

Water cages and amphipathic molecules

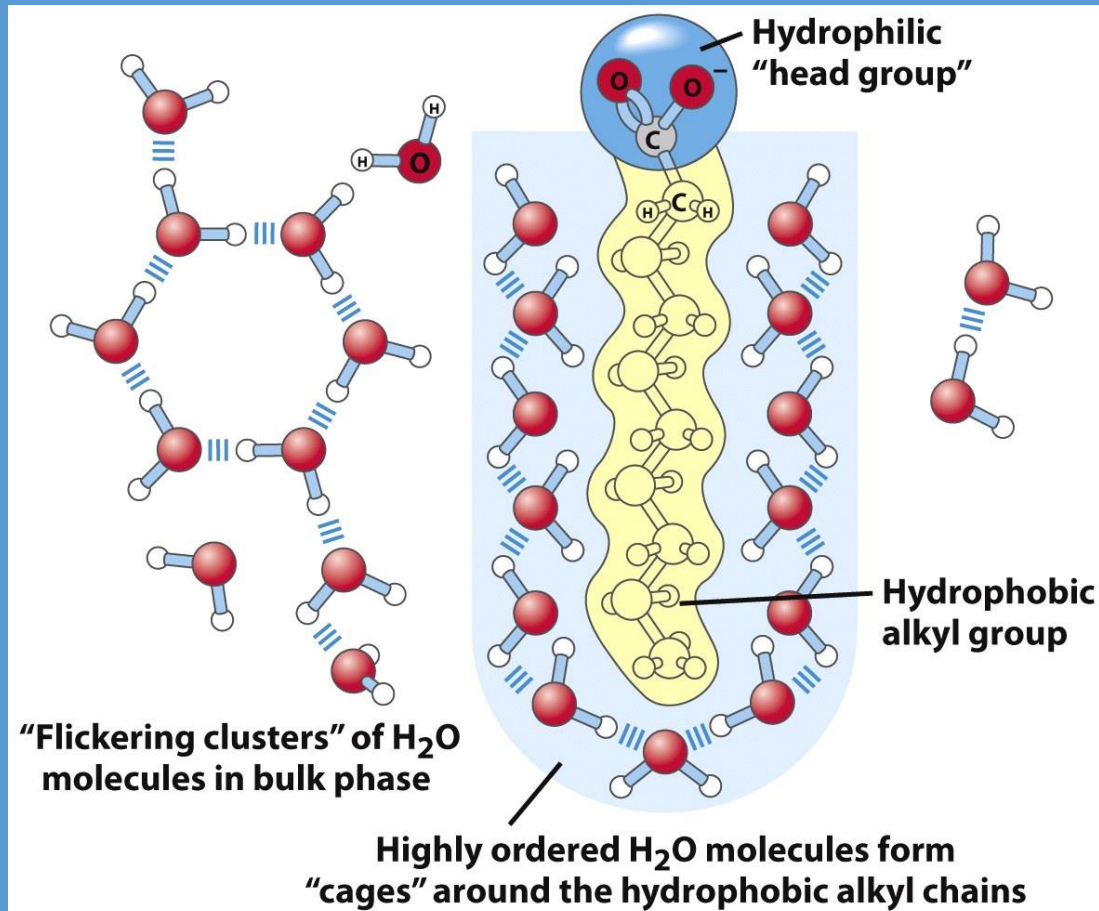
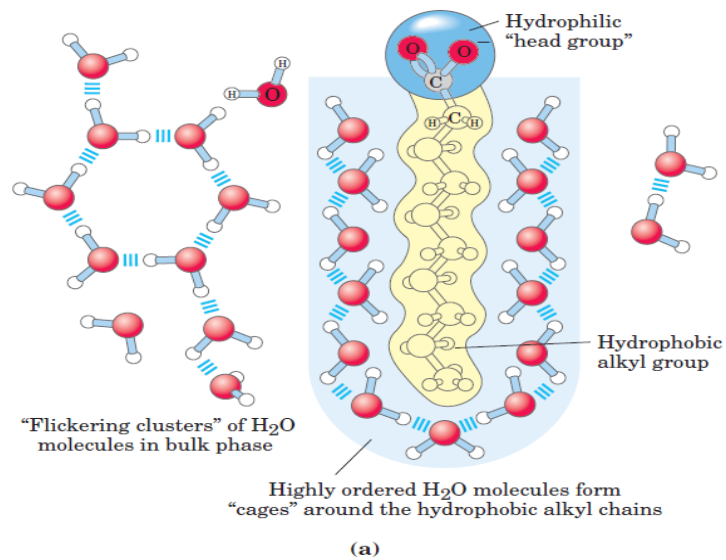


Figure 2-7a  
Lehninger Principles of Biochemistry, Fifth Edition  
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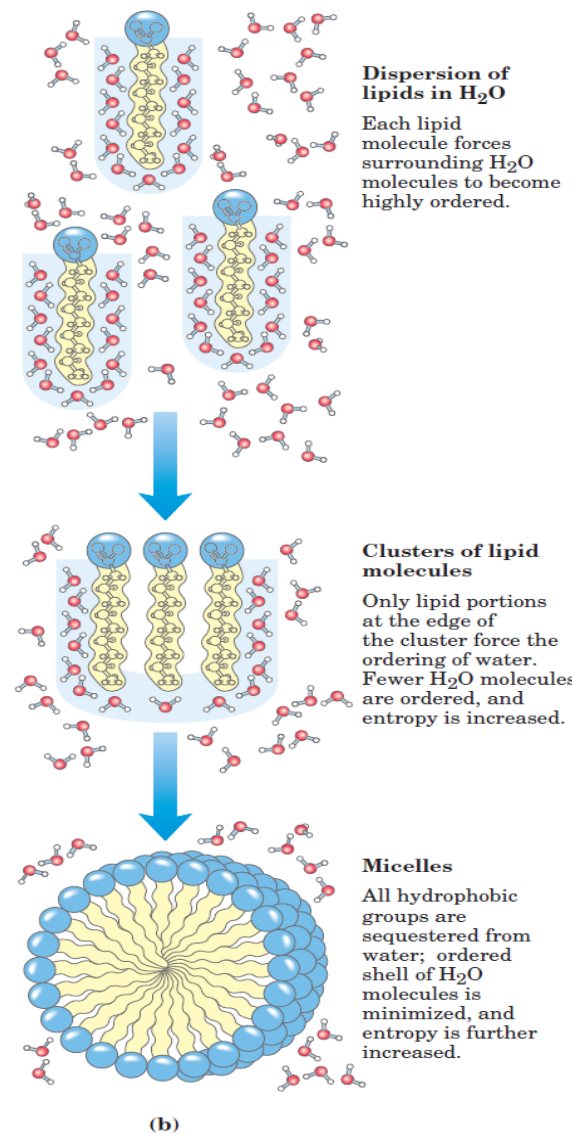
- آب و مولکول های قطبی
- آب و واکنش های شیمیایی
- Hydrophile
- Hydrophobe
- Amphipathic
- واکنش های متقابل آبریز
- آب به عنوان واکنشگر
- واکنش های کندانیون
- واکنش های هیدرولیز
- آب متابولیک



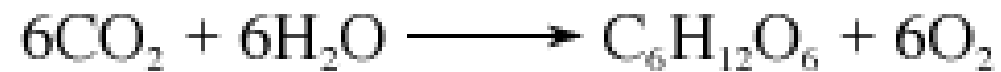
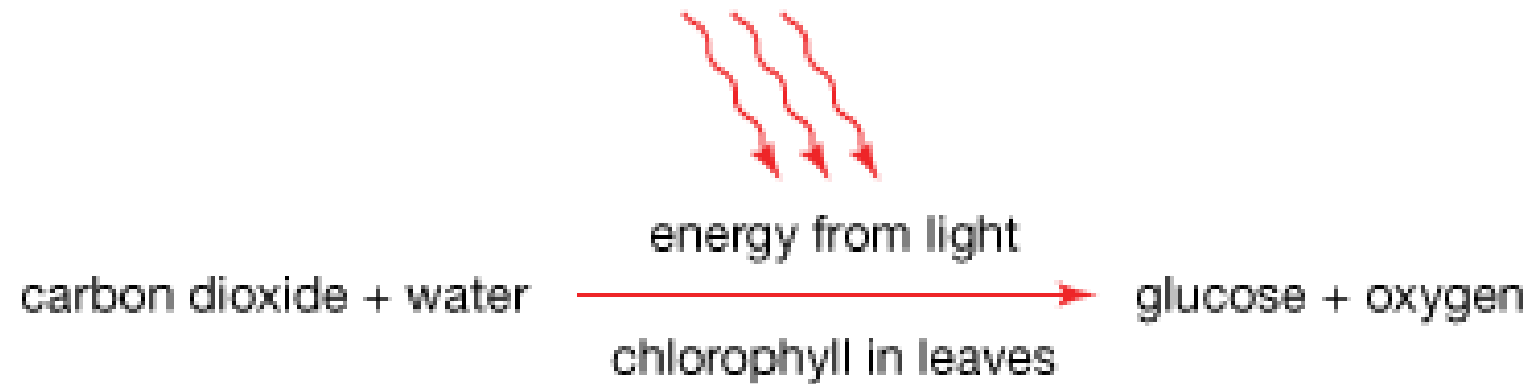
# Water cages and amphipathic molecules



**FIGURE 2-7 Amphipathic compounds in aqueous solution.** (a) Long-chain fatty acids have very hydrophobic alkyl chains, each of which is surrounded by a layer of highly ordered water molecules. (b) By clustering together in micelles, the fatty acid molecules expose the smallest possible hydrophobic surface area to the water, and fewer water molecules are required in the shell of ordered water. The energy gained by freeing immobilized water molecules stabilizes the micelle.



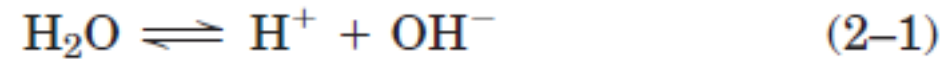
## The reaction of photosynthesis



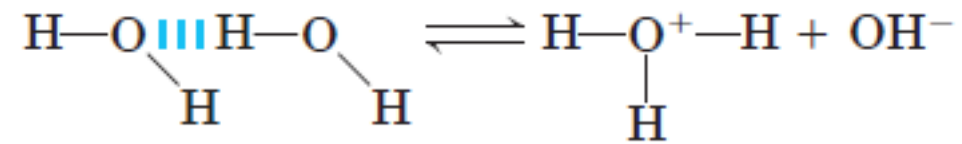
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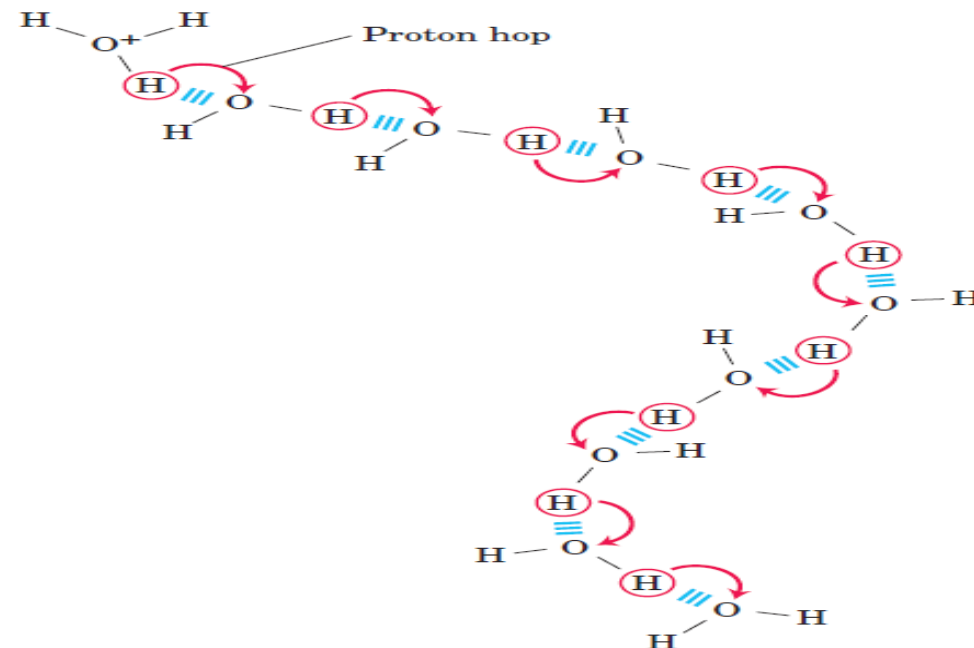
## یونیزاسیون آب، اسیدها و بازهای ضعیف



### hydronium ions ( $\text{H}_3\text{O}^+$ )



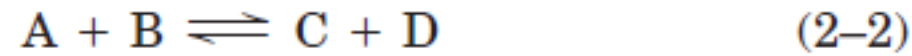
Hydronium ion gives up a proton



Water accepts proton and becomes a hydronium ion

## یونیزاسیون آب، اسیدها و بازهای ضعیف

equilibrium constant,  $K_{eq}$



$$K_{eq} = \frac{[C][D]}{[A][B]}$$

$$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]} \quad (2-3)$$

$$K_{eq} = \frac{[H^+][OH^-]}{55.5 \text{ M}},$$

واکنش تعادلی:

ثابت تعادل آب:

وزن مولکولی آب  
 $18 = \text{g/mol}$

## یونیزاسیون آب، اسیدها و بازهای ضعیف

$$(55.5 \text{ M})(K_{\text{eq}}) = [\text{H}^+][\text{OH}^-] = K_w \quad (2-4)$$

$$\begin{aligned} K_w &= [\text{H}^+][\text{OH}^-] = (55.5 \text{ M})(1.8 \times 10^{-16} \text{ M}) \\ &= 1.0 \times 10^{-14} \text{ M}^2 \end{aligned}$$

$$K_w = [\text{H}^+][\text{OH}^-] = [\text{H}^+]^2$$

Solving for  $[\text{H}^+]$  gives

$$[\text{H}^+] = \sqrt{K_w} = \sqrt{1 \times 10^{-14} \text{ M}^2}$$

$$[\text{H}^+] = [\text{OH}^-] = 10^{-7} \text{ M}$$

## اسیدیتہ (pH):

$$\text{pH} = \log \frac{1}{[\text{H}^+]} = -\log [\text{H}^+]$$

$$\begin{aligned}\text{pH} &= \log \frac{1}{1.0 \times 10^{-7}} = \log (1.0 \times 10^7) \\ &= \log 1.0 + \log 10^7 = 0 + 7 = 7\end{aligned}$$



# اسیدیتہ (pH):

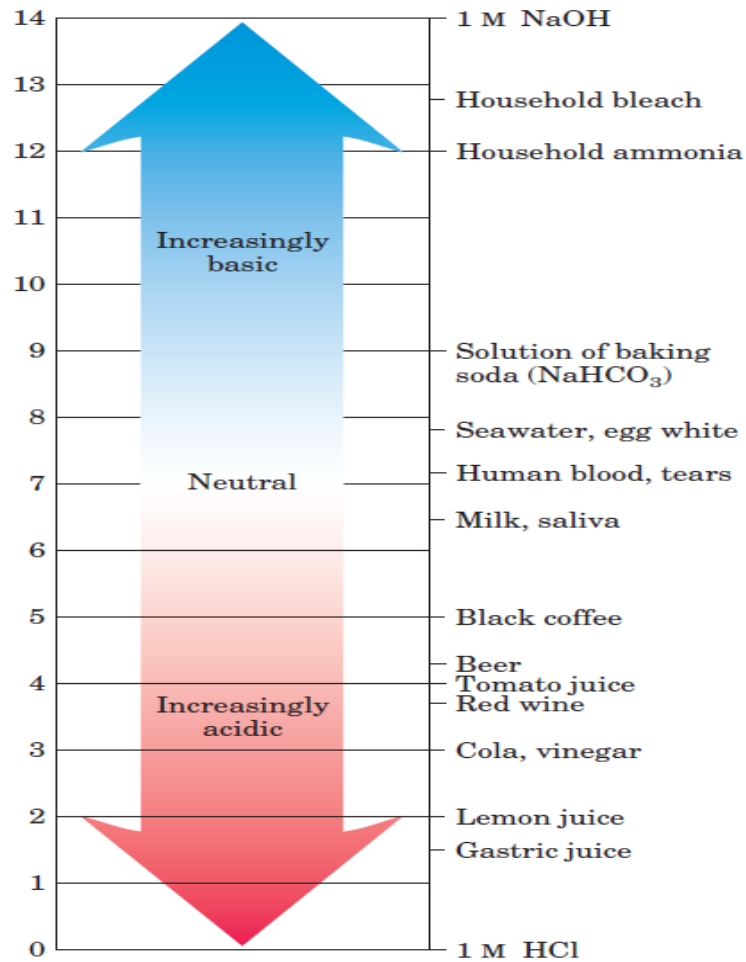


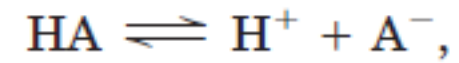
FIGURE 2-15 The pH of some aqueous fluids.

TABLE 2-6 The pH Scale

$[H^+]$ (M)	pH	$[OH^-]$ (M)	pOH*
$10^0$ (1)	0	$10^{-14}$	14
$10^{-1}$	1	$10^{-13}$	13
$10^{-2}$	2	$10^{-12}$	12
$10^{-3}$	3	$10^{-11}$	11
$10^{-4}$	4	$10^{-10}$	10
$10^{-5}$	5	$10^{-9}$	9
$10^{-6}$	6	$10^{-8}$	8
$10^{-7}$	7	$10^{-7}$	7
$10^{-8}$	8	$10^{-6}$	6
$10^{-9}$	9	$10^{-5}$	5
$10^{-10}$	10	$10^{-4}$	4
$10^{-11}$	11	$10^{-3}$	3
$10^{-12}$	12	$10^{-2}$	2
$10^{-13}$	13	$10^{-1}$	1
$10^{-14}$	14	$10^0$ (1)	0

\*The expression pOH is sometimes used to describe the basicity, or  $OH^-$  concentration, of a solution; pOH is defined by the expression  $pOH = -\log [OH^-]$ , which is analogous to the expression for pH. Note that in all cases,  $pH + pOH = 14$ .

ثابت تفکیک اسید و باز ضعیف ( $K_a$ ):



$$K_{\text{eq}} = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} = K_a$$

$$\text{p}K_a = \log \frac{1}{K_a} = -\log K_a$$

## معادله هندرسون-هاسلباخ



$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

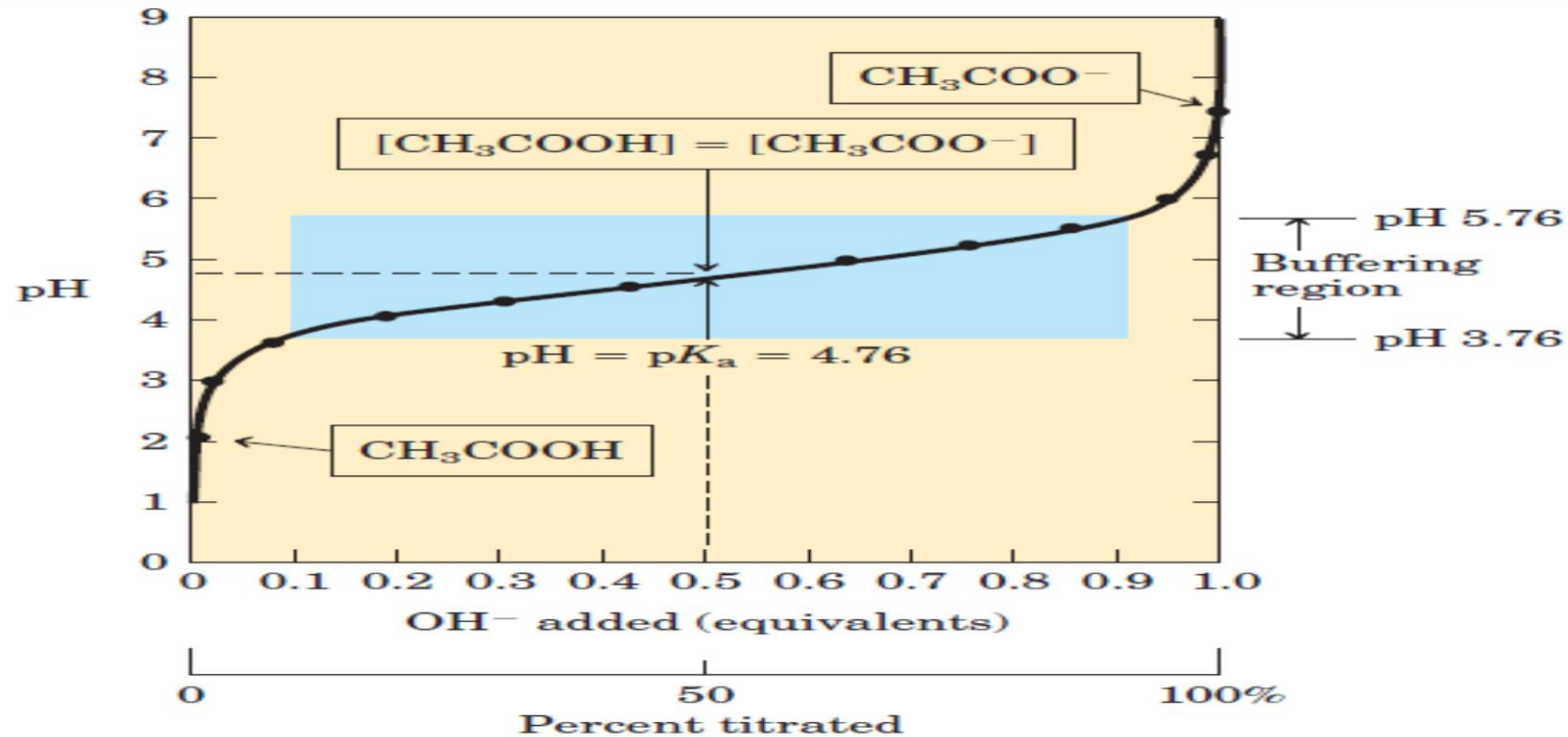
$$[\text{H}^+] = K_a \frac{[\text{HA}]}{[\text{A}^-]}$$

$$-\log [\text{H}^+] = -\log K_a - \log \frac{[\text{HA}]}{[\text{A}^-]}$$

$$\text{pH} = \text{p}K_a - \log \frac{[\text{HA}]}{[\text{A}^-]}$$

$$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

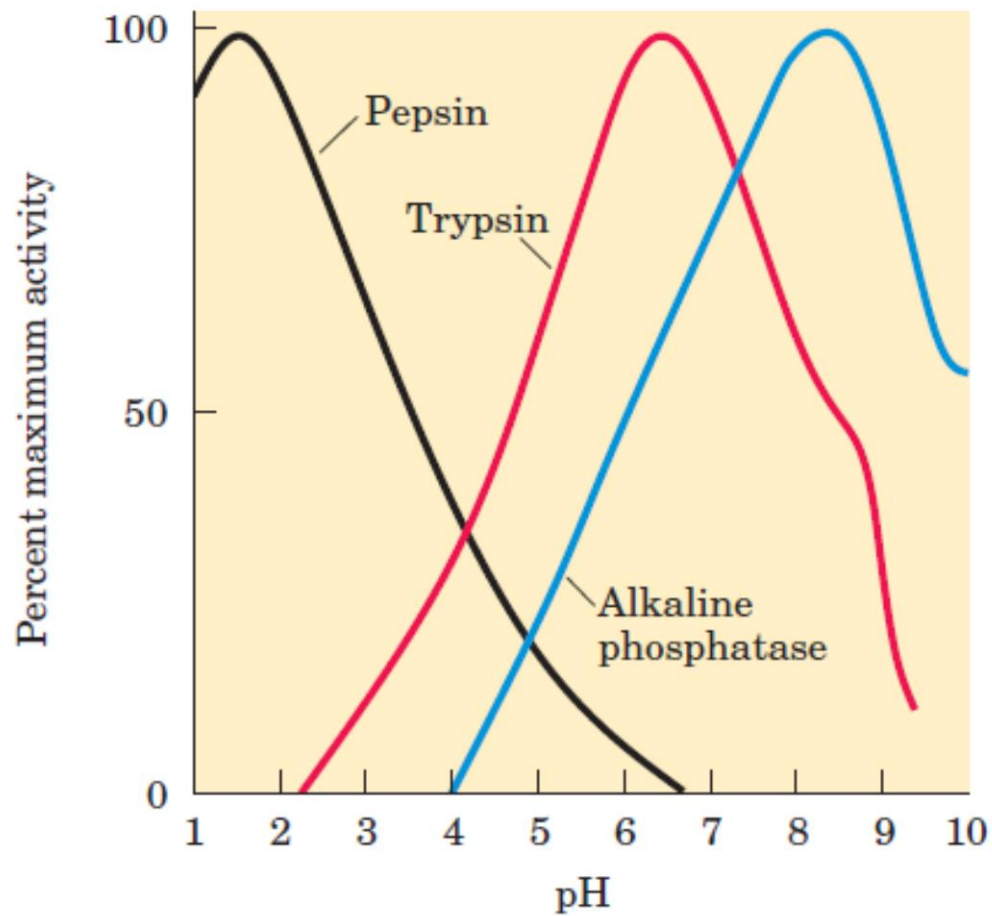
## منحنی تیتراسیون اسید استیک



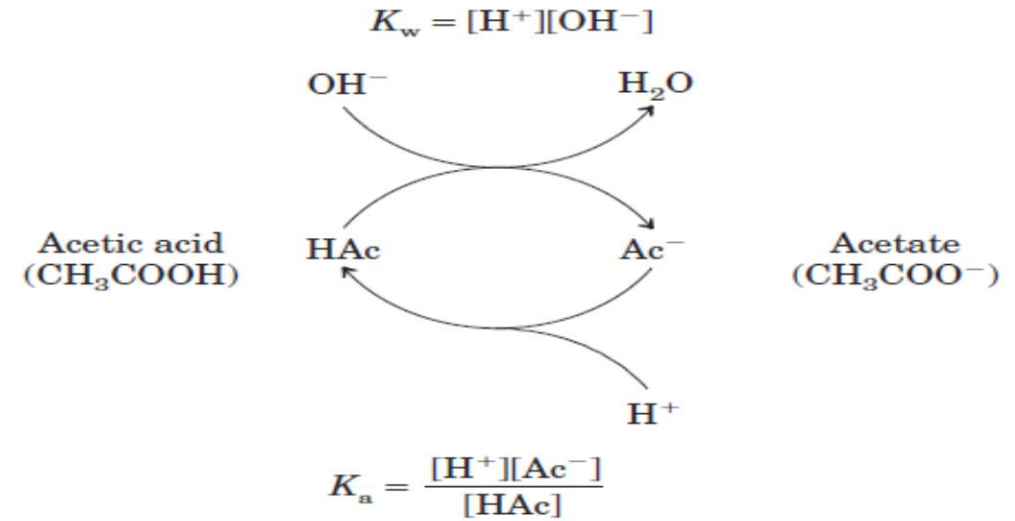
**FIGURE 2-17** The titration curve of acetic acid. After addition of each increment of NaOH to the acetic acid solution, the pH of the mixture is measured. This value is plotted against the amount of NaOH expressed as a fraction of the total NaOH required to convert all the acetic acid to its deprotonated form, acetate. The points so obtained yield the titration curve. Shown in the boxes are the predominant ionic forms at the points designated. At the midpoint of the titration, the concentrations of the proton donor and proton acceptor are equal, and the pH is numerically equal to the  $pK_a$ . The shaded zone is the useful region of buffering power, generally between 10% and 90% titration of the weak acid.



## بافر (تامپون)

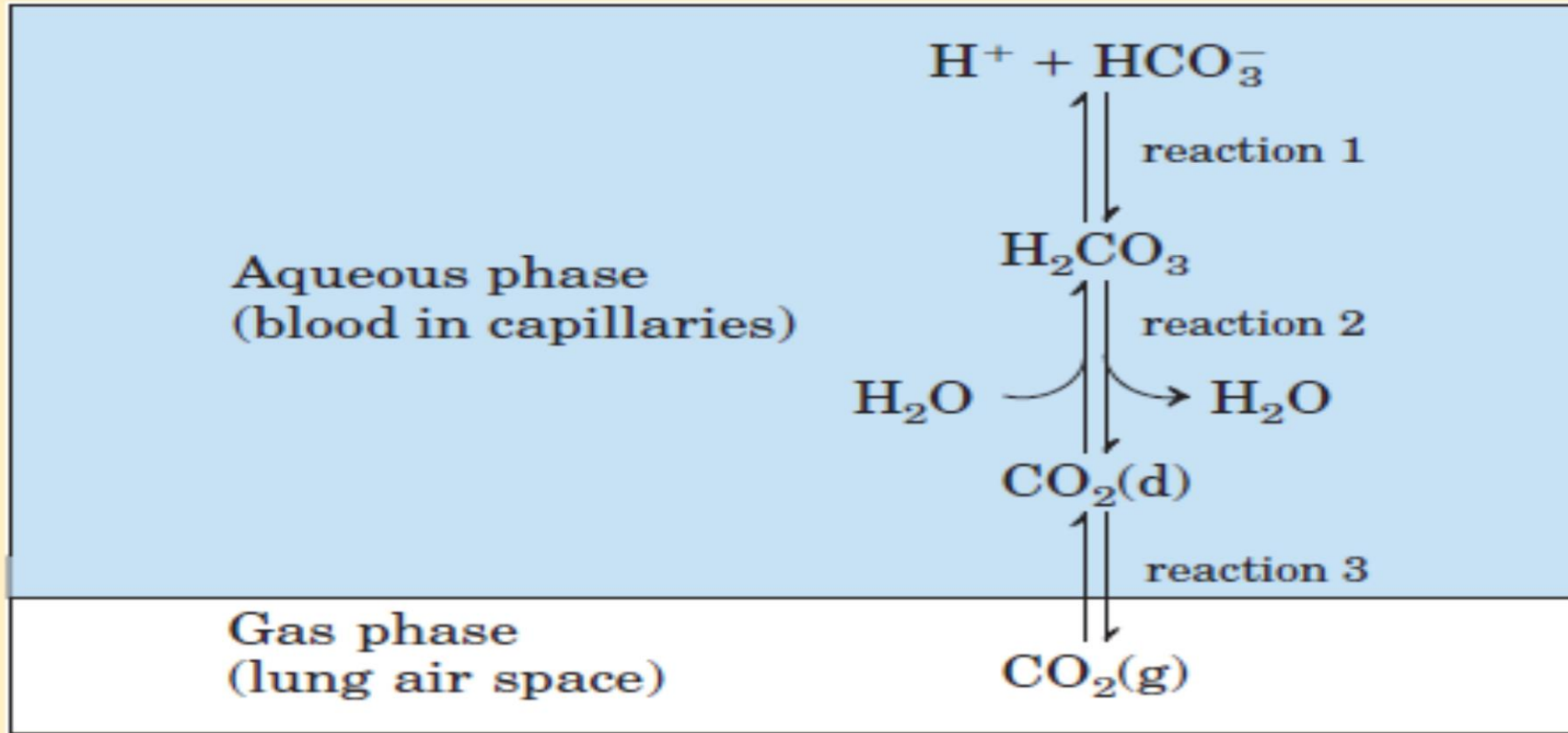


**FIGURE 2-21** The pH optima of some enzymes. Pepsin is a digestive enzyme secreted into gastric juice; trypsin, a digestive enzyme that acts in the small intestine; alkaline phosphatase of bone tissue, a hydrolytic enzyme thought to aid in bone mineralization.



**FIGURE 2-19** The acetic acid–acetate pair as a buffer system. The system is capable of absorbing either H<sup>+</sup> or OH<sup>-</sup> through the reversibility of the dissociation of acetic acid. The proton donor, acetic acid (HAc), contains a reserve of bound H<sup>+</sup>, which can be released to neutralize an addition of OH<sup>-</sup> to the system, forming H<sub>2</sub>O. This happens because the product [H<sup>+</sup>][OH<sup>-</sup>] transiently exceeds  $K_w$  ( $1 \times 10^{-14} \text{ M}^2$ ). The equilibrium quickly adjusts so that this product equals  $1 \times 10^{-14} \text{ M}^2$  (at 25 °C), thus transiently reducing the concentration of H<sup>+</sup>. But now the quotient  $[\text{H}^+][\text{Ac}^-] / [\text{HAc}]$  is less than  $K_a$ , so HAc dissociates further to restore equilibrium. Similarly, the conjugate base, Ac<sup>-</sup>, can react with H<sup>+</sup> ions added to the system; again, the two ionization reactions simultaneously come to equilibrium. Thus a conjugate acid–base pair, such as acetic acid and acetate ion, tends to resist a change in pH when small amounts of acid or base are added. Buffering action is simply the consequence of two reversible reactions taking place simultaneously and reaching their points of equilibrium as governed by their equilibrium constants,  $K_w$  and  $K_a$ .

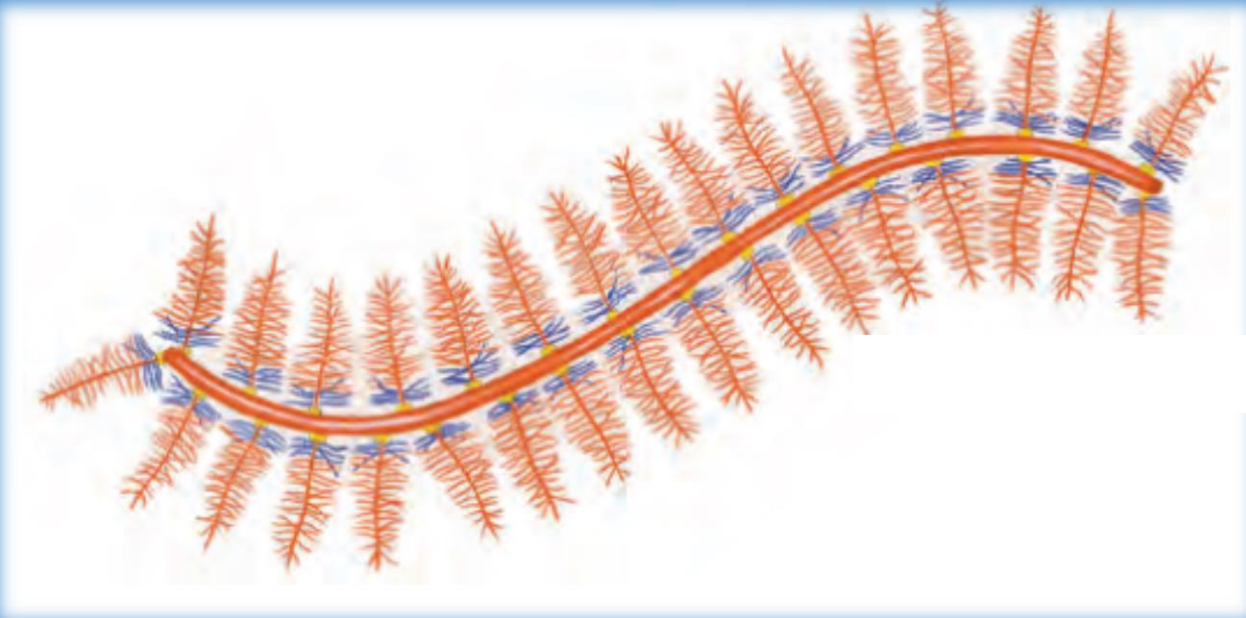
## بافر (تامپون)



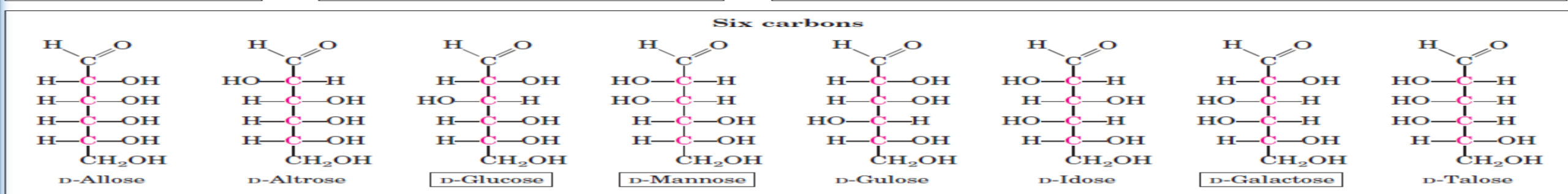
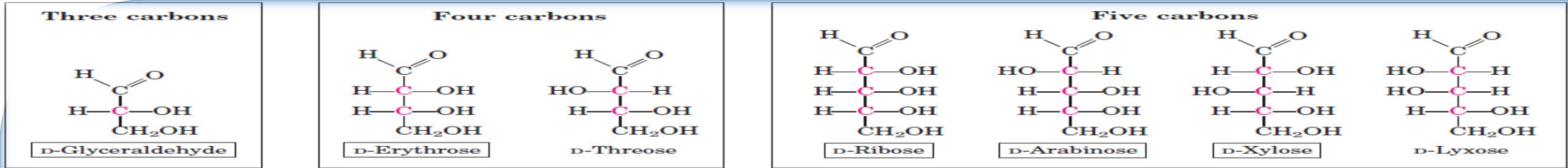
**FIGURE 1** The  $\text{CO}_2$  in the air space of the lungs is in equilibrium with the bicarbonate buffer in the blood plasma passing through the lung capillaries. Because the concentration of dissolved  $\text{CO}_2$  can be adjusted rapidly through changes in the rate of breathing, the bicarbonate buffer system of the blood is in near-equilibrium with a large potential reservoir of  $\text{CO}_2$ .

# کربوهیدرات‌ها: ✓

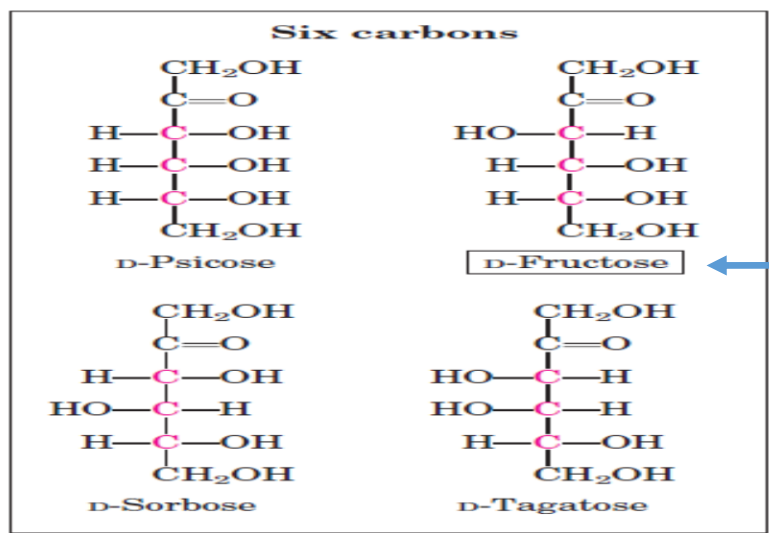
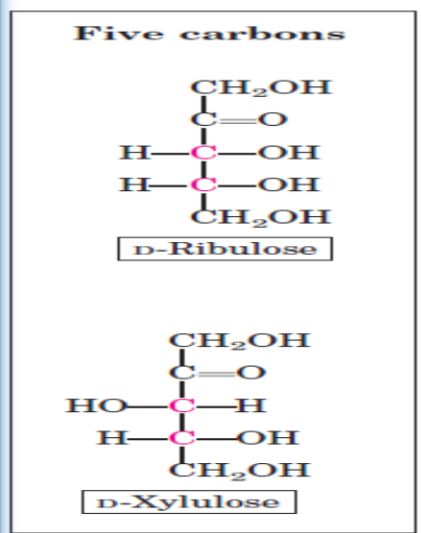
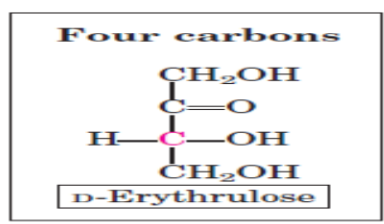
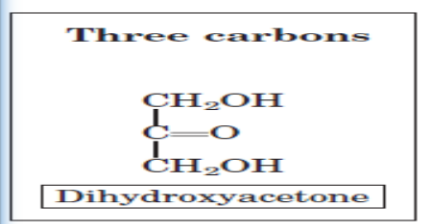
- اهمیت
- ویژگی‌ها
- ساختمان شیمیایی







**D-Aldoses (a)**

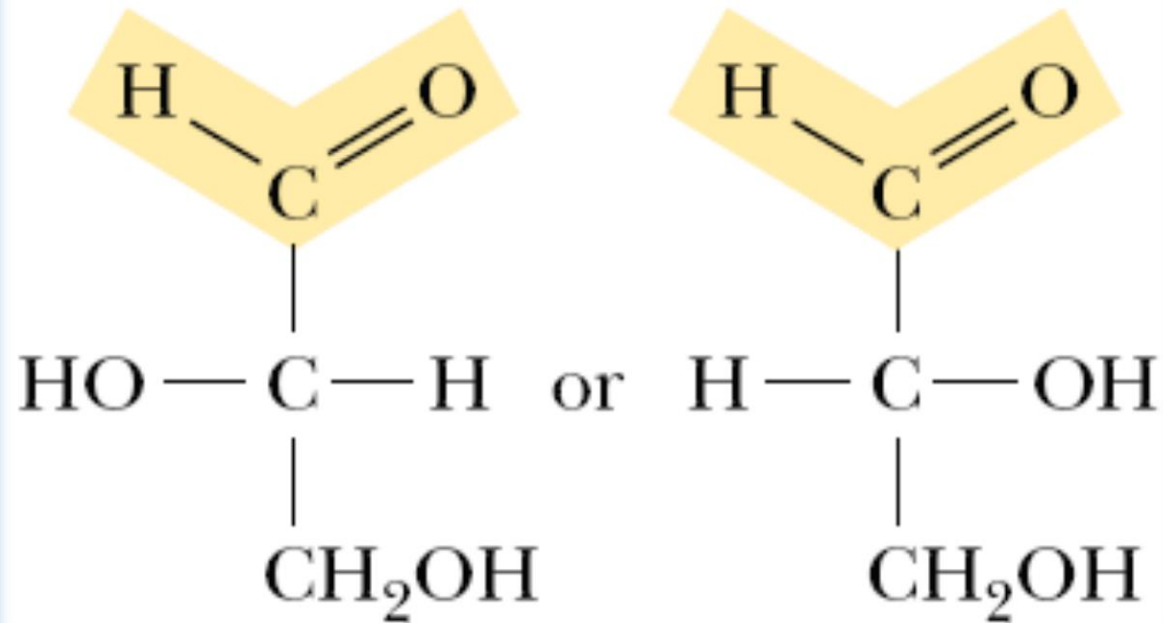


**D-Ketoses**

**FIGURE 7-3 Aldoses and ketoses.** The series of (a) D-aldoses and (b) D-ketoses having from three to six carbon atoms, shown as projection formulas. The carbon atoms in red are chiral centers. In all these D isomers, the chiral carbon most distant from the carbonyl carbon has the same configuration as the chiral carbon in D-glyceraldehyde. The sugars named in boxes are the most common in nature; you will encounter these again in this and later chapters.

مونوساكاريدها:

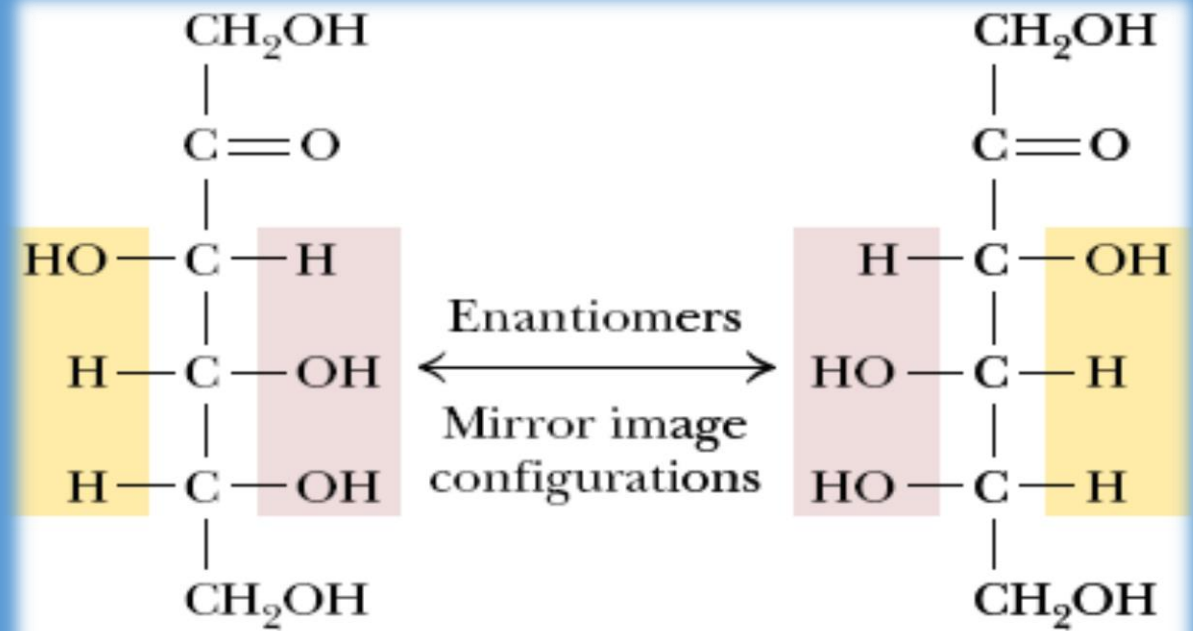
# شیمی فضایی مونوساکاریدها:



**L-isomer**

**D-isomer**

**Glyceraldehyde**

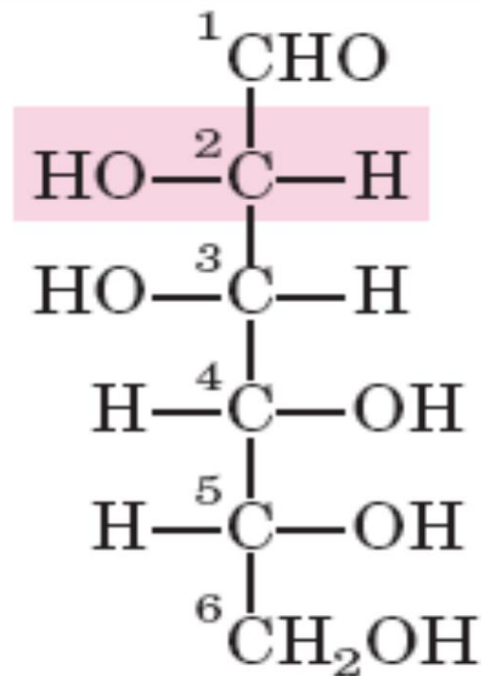


**D-Fructose**

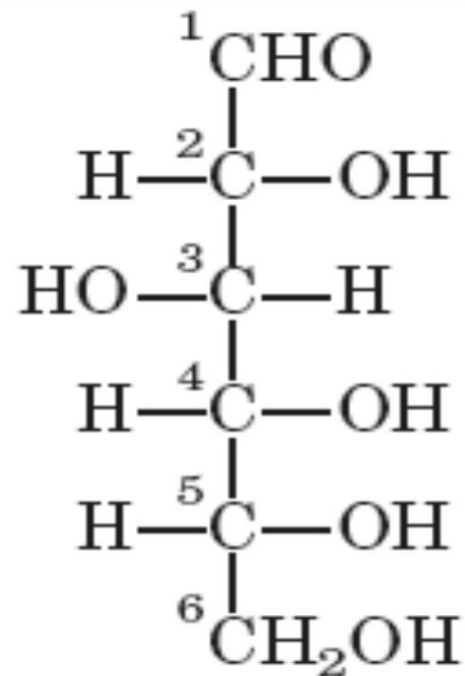
**L-Fructose**

**FIGURE 7.4** • D-Fructose and L-fructose, an enantiomeric pair. Note that changing the configuration only at C<sub>5</sub> would change D-fructose to L-sorbose.

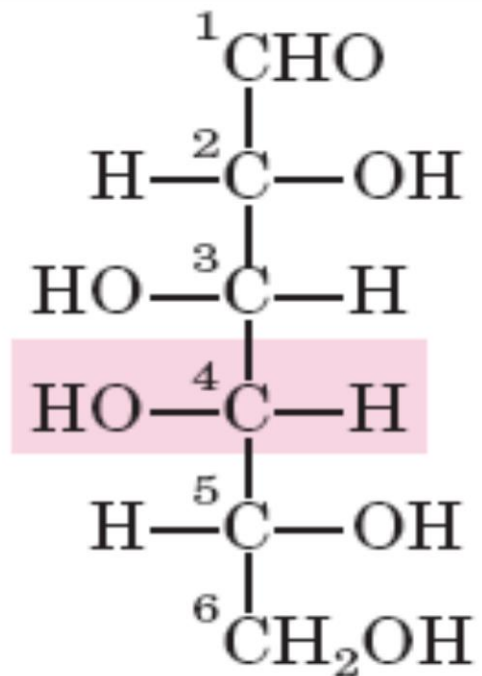
## اپی مر در مونوساکاریدها:



D-Mannose  
(epimer at C-2)



D-Glucose



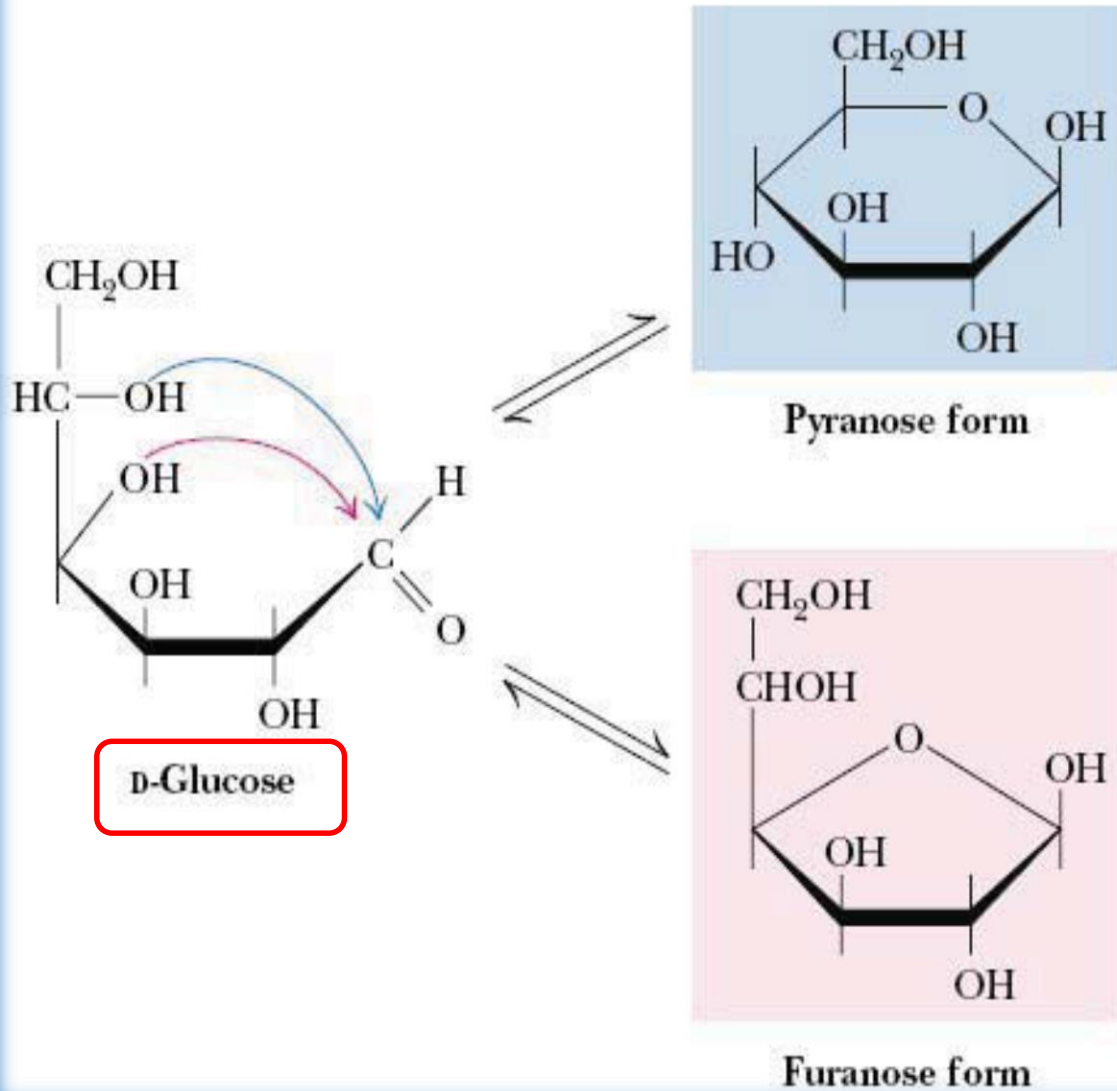
D-Galactose  
(epimer at C-4)

**FIGURE 7-4 Epimers.** D-Glucose and two of its epimers are shown as projection formulas. Each epimer differs from D-glucose in the configuration at one chiral center (shaded red).



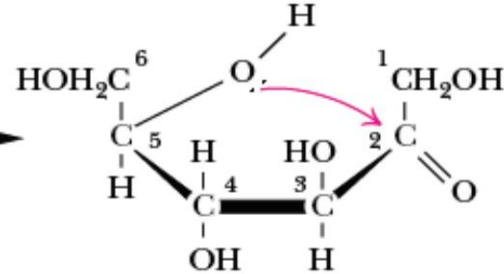
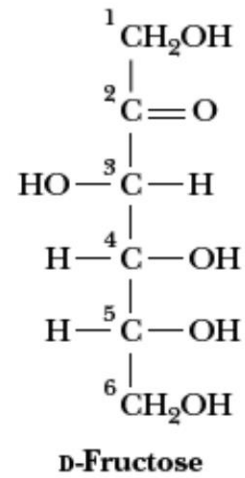
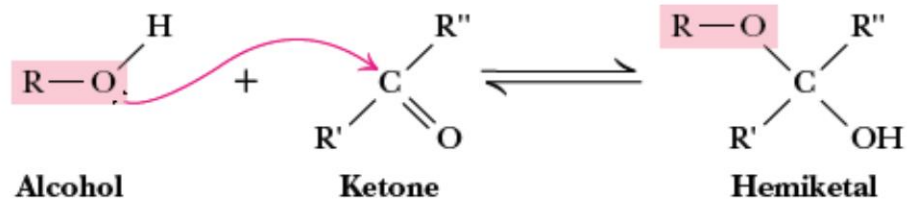


# ساختار حلقوی و فرم‌های آنومری در مونوساکاریدها:

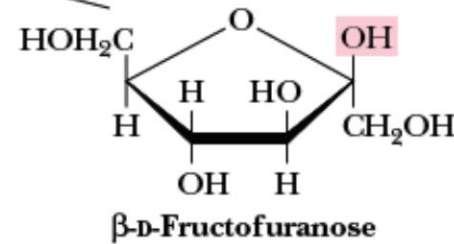
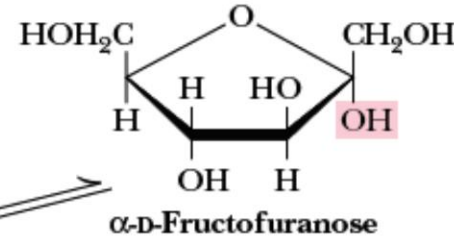


**FIGURE 7.7** • D-Glucose can cyclize in two ways, forming either furanose or pyranose structures.

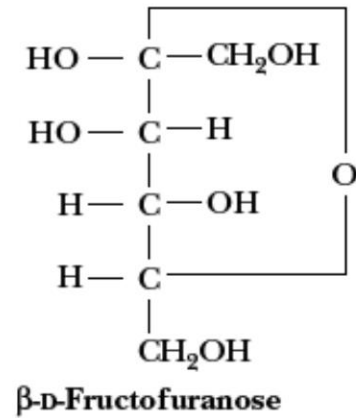
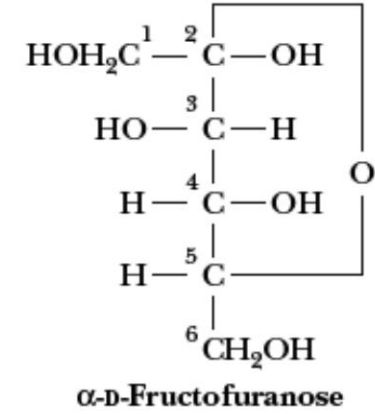
# ساختار حلقوی و فرم‌های آنومری در مونوساکاریدها:



Cyclization

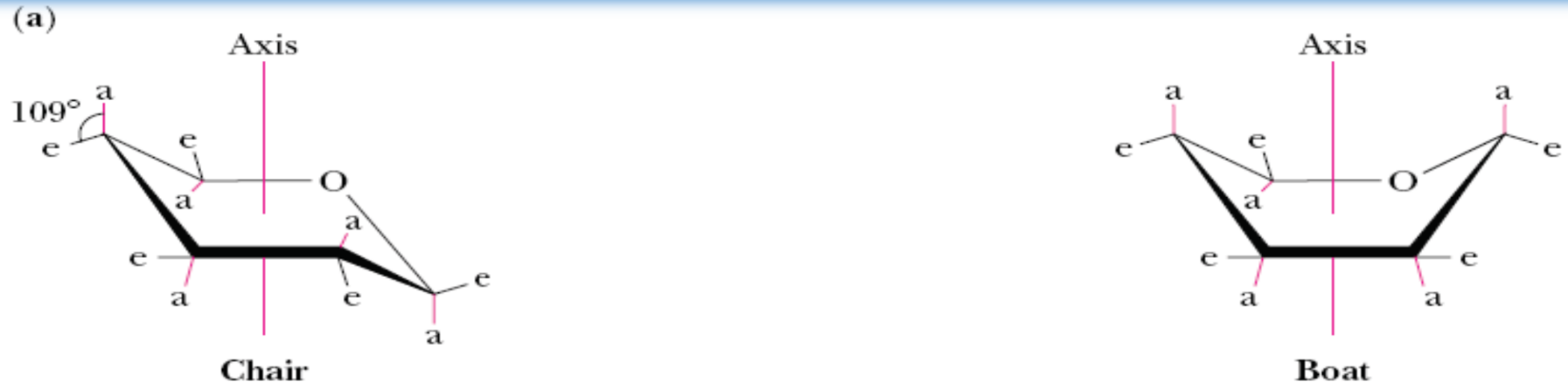


HAWORTH PROJECTION FORMULAS



FISCHER PROJECTION FORMULAS

# پایداری ساختار حلقوی در مونوساکاریدها:

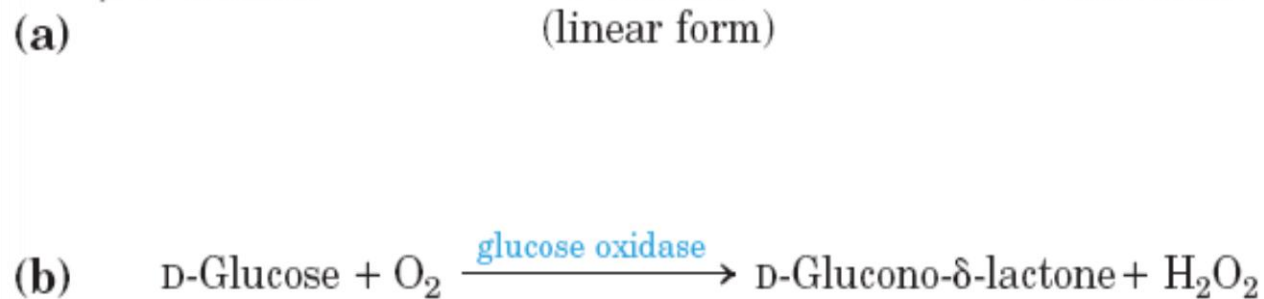
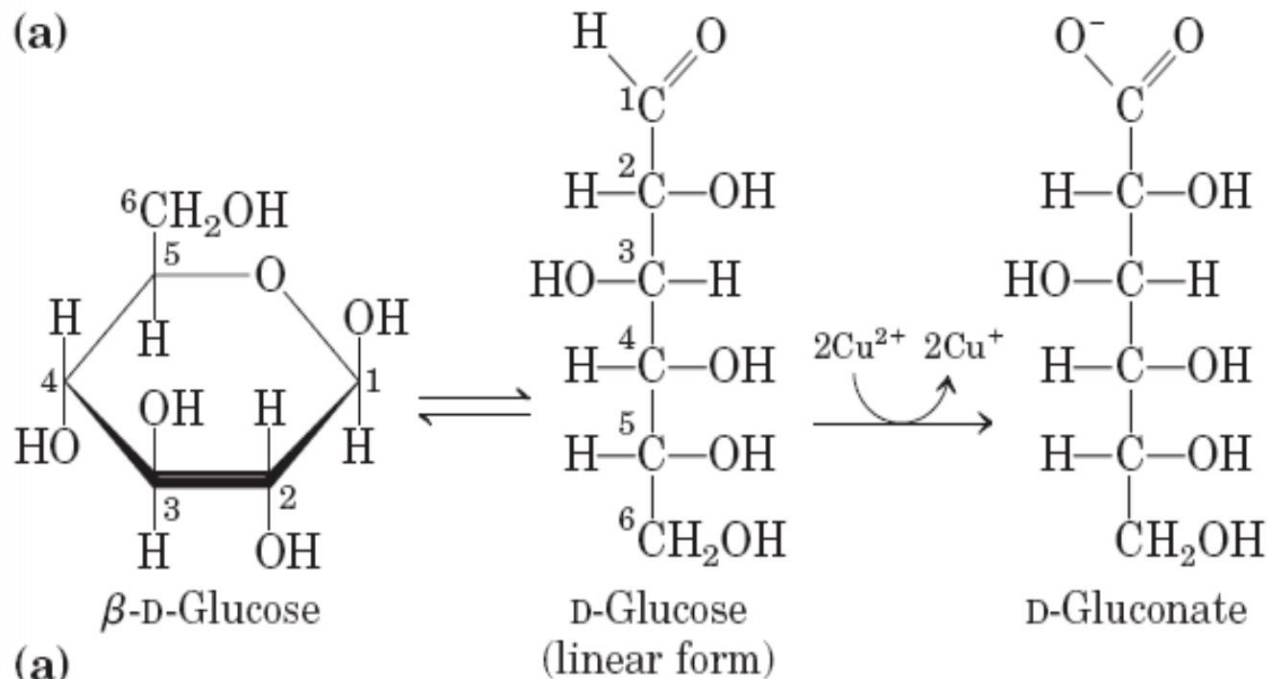


a = axial bond  
e = equatorial bond



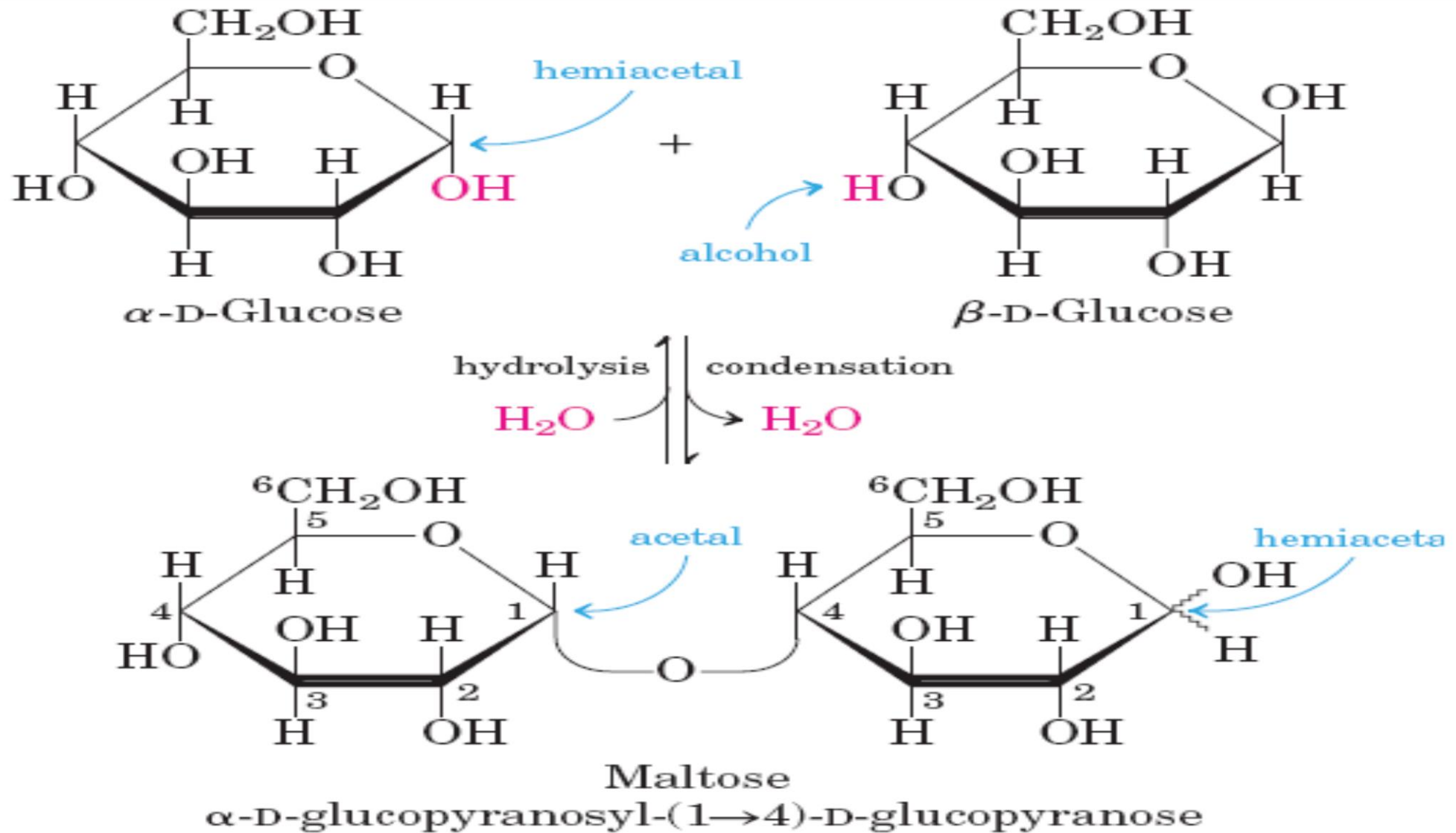
**FIGURE 7.9** • (a) Chair and boat conformations of a pyranose sugar. (b) Two possible chair conformations of  $\beta$ -D-glucose.

# خاصیت احیاء کنندگی در مونوساکاریدها:



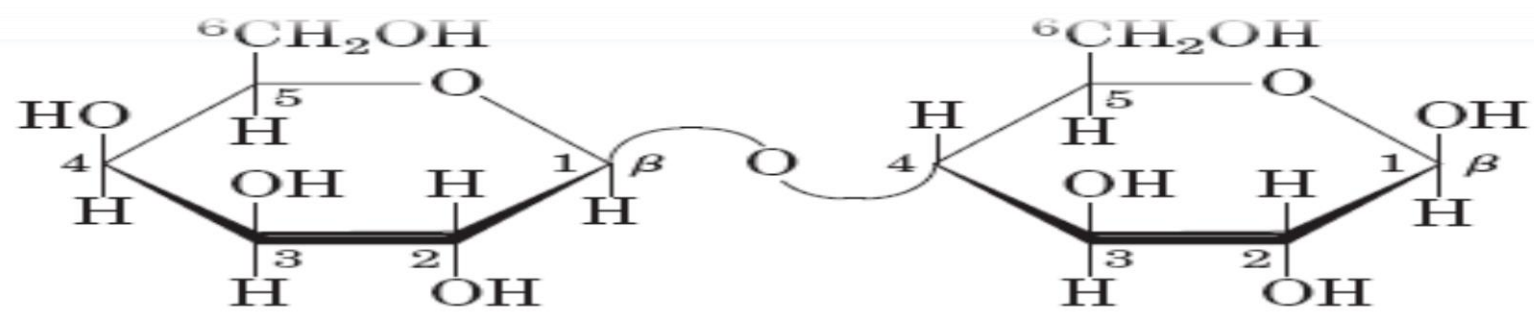
**FIGURE 7-10** Sugars as reducing agents. (a) Oxidation of the anomeric carbon of glucose and other sugars is the basis for Fehling's reaction. The cuprous ion ( $\text{Cu}^+$ ) produced under alkaline conditions forms a red cuprous oxide precipitate. In the hemiacetal (ring) form, C-1 of glucose cannot be oxidized by  $\text{Cu}^{2+}$ . However, the open-chain form is in equilibrium with the ring form, and eventually the oxidation reaction goes to completion. The reaction with  $\text{Cu}^{2+}$  is not as simple as the equation here implies; in addition to D-gluconate, a number of shorter-chain acids are produced by the fragmentation of glucose. (b) Blood glucose concentration is commonly determined by measuring the amount of  $\text{H}_2\text{O}_2$  produced in the reaction catalyzed by glucose oxidase. In the reaction mixture, a second enzyme, peroxidase, catalyzes reaction of the  $\text{H}_2\text{O}_2$  with a colorless compound to produce a colored compound, the amount of which is then measured spectrophotometrically.

# الیگوساکاریڈھا:



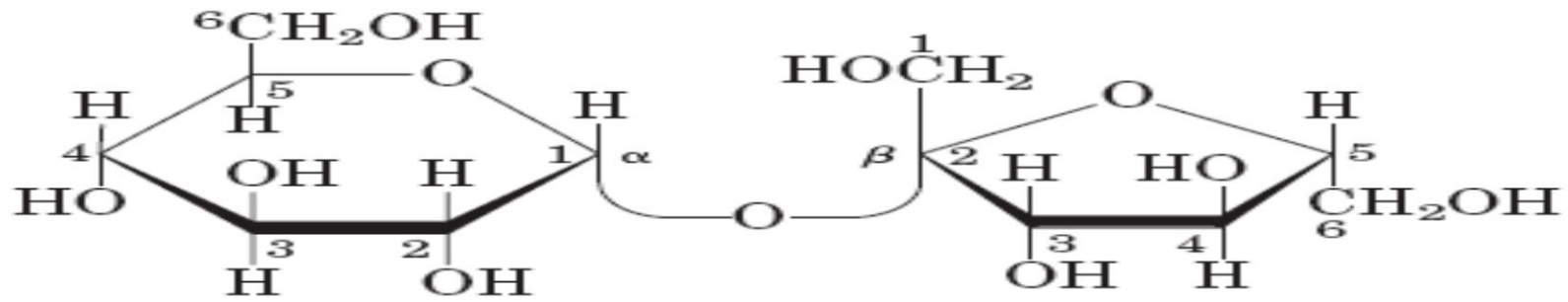
**FIGURE 7-11** Formation of maltose.





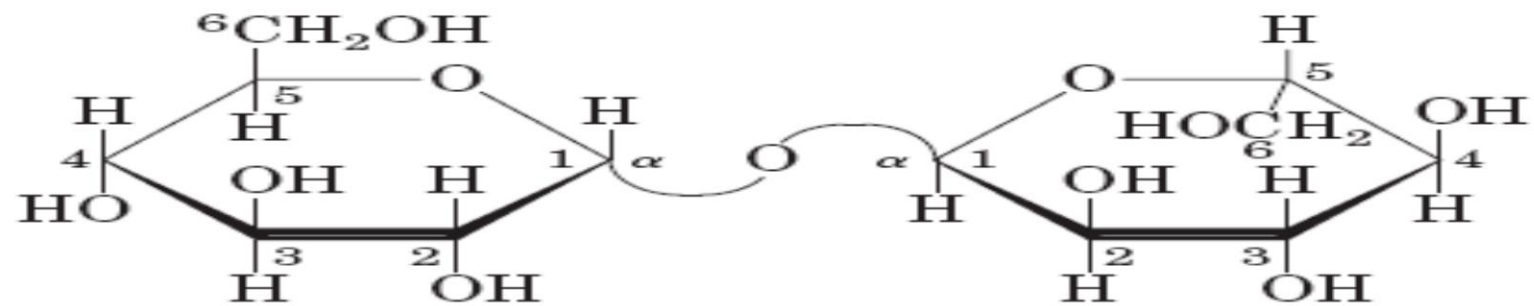
Lactose ( $\beta$  form)

$\beta$ -D-galactopyranosyl-(1 $\rightarrow$ 4)- $\beta$ -D-glucopyranoside  
Gal( $\beta$ 1 $\rightarrow$ 4)Glc



Sucrose

$\alpha$ -D-glucopyranosyl  $\beta$ -D-fructofuranoside  
Glc( $\alpha$ 1 $\leftrightarrow$ 2 $\beta$ )Fru



Trehalose

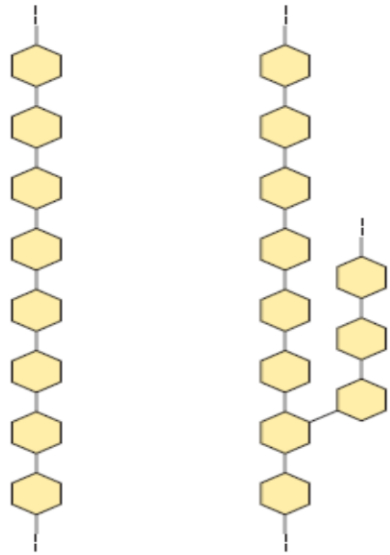
$\alpha$ -D-glucopyranosyl  $\alpha$ -D-glucopyranoside  
Glc( $\alpha$ 1 $\leftrightarrow$ 1 $\alpha$ )Glc

FIGURE 7-12 Some common disaccharides.

# پلی ساکاریدھا:

## Homopolysaccharides

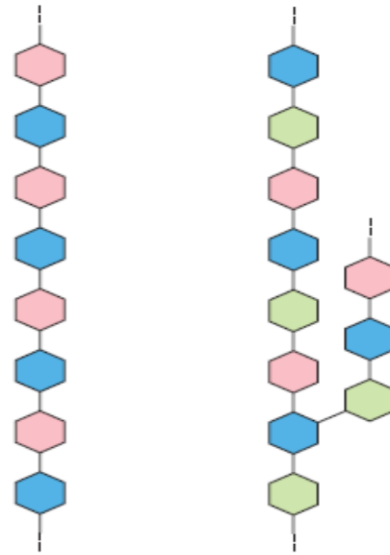
Unbranched    Branched



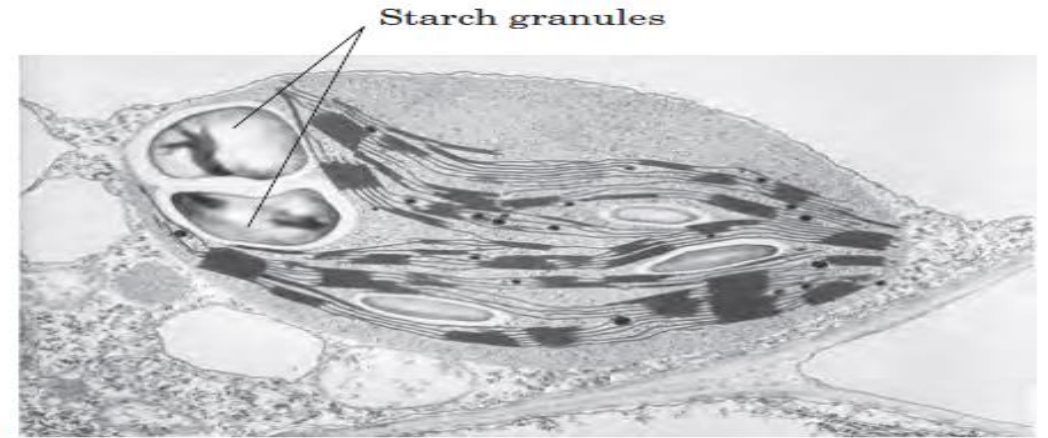
## Heteropolysaccharides

Two monomer types, unbranched

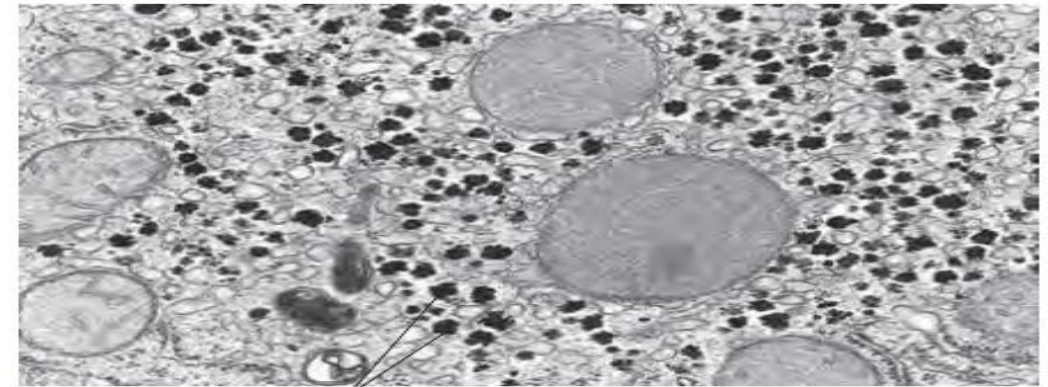
Multiple monomer types, branched



**FIGURE 7-13** Homo- and heteropolysaccharides. Polysaccharides may be composed of one, two, or several different monosaccharides, in straight or branched chains of varying length.



(a)

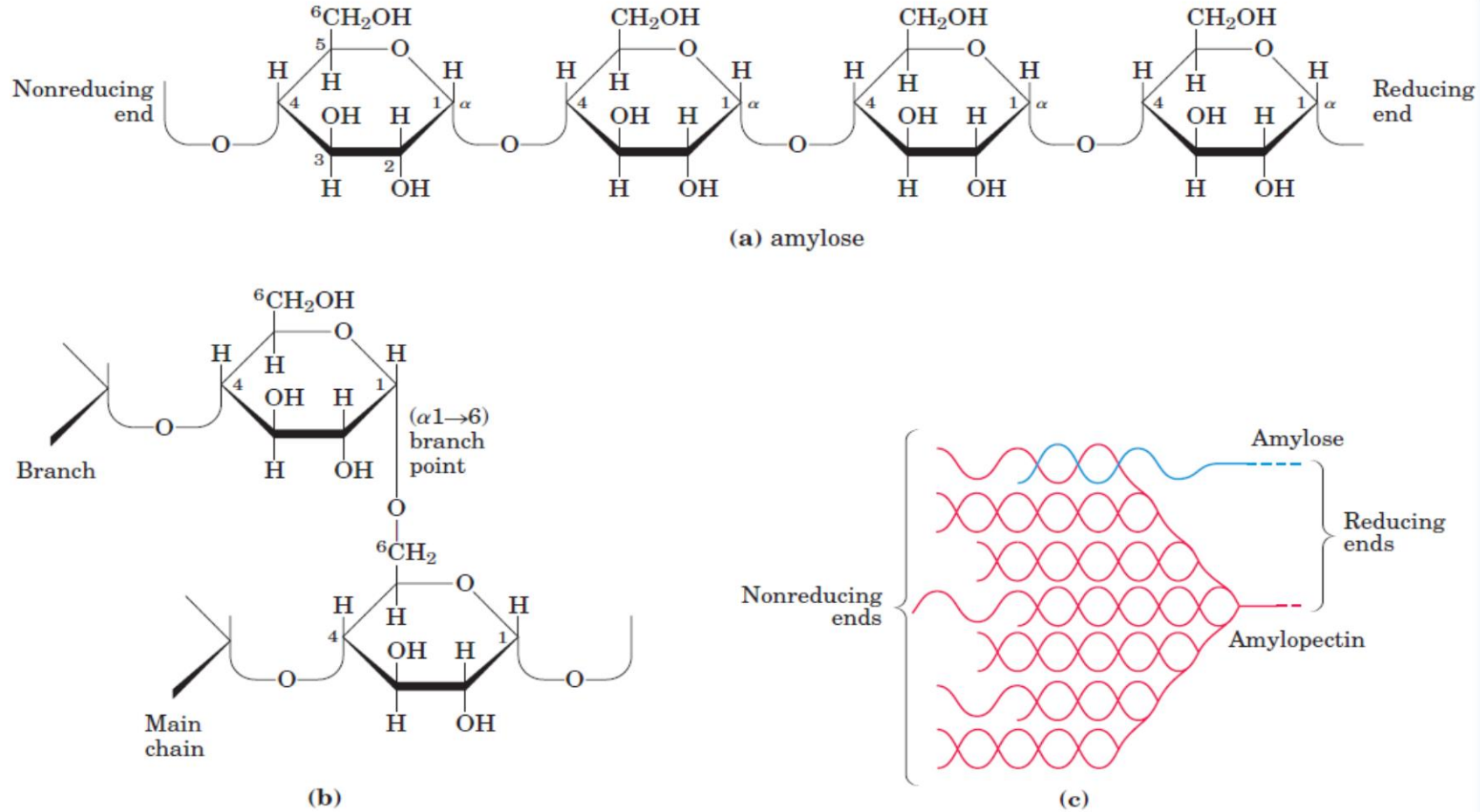


(b)

Glycogen granules

**FIGURE 7-14** Electron micrographs of starch and glycogen granules. (a) Large starch granules in a single chloroplast. Starch is made in the chloroplast from D-glucose formed photosynthetically. (b) Glycogen granules in a hepatocyte. These granules form in the cytosol and are much smaller ( $\sim 0.1 \mu\text{m}$ ) than starch granules ( $\sim 1.0 \mu\text{m}$ ).

# نشاسته (آمیلوز + آمیلوپکتین):

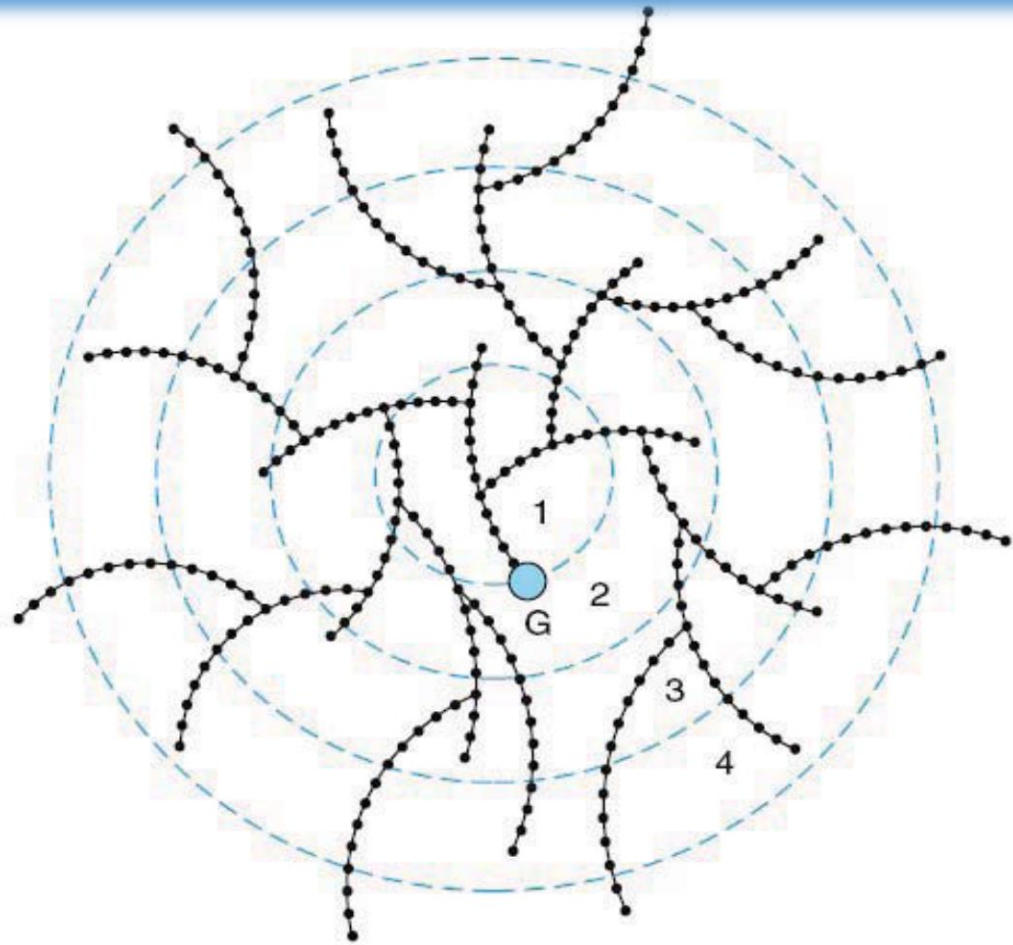


**FIGURE 7-15** Amylose and amylopectin, the polysaccharides of starch. (a) A short segment of amylose, a linear polymer of D-glucose residues in  $(\alpha 1 \rightarrow 4)$  linkage. A single chain can contain several thousand glucose residues. Amylopectin has stretches of similarly linked residues between branch points. (b) An  $(\alpha 1 \rightarrow 6)$  branch point of amylopectin. (c) A cluster of amylose and amylopectin like that believed

to occur in starch granules. Strands of amylopectin (red) form double-helical structures with each other or with amylose strands (blue). Glucose residues at the nonreducing ends of the outer branches are removed enzymatically during the mobilization of starch for energy production. Glycogen has a similar structure but is more highly branched and more compact.

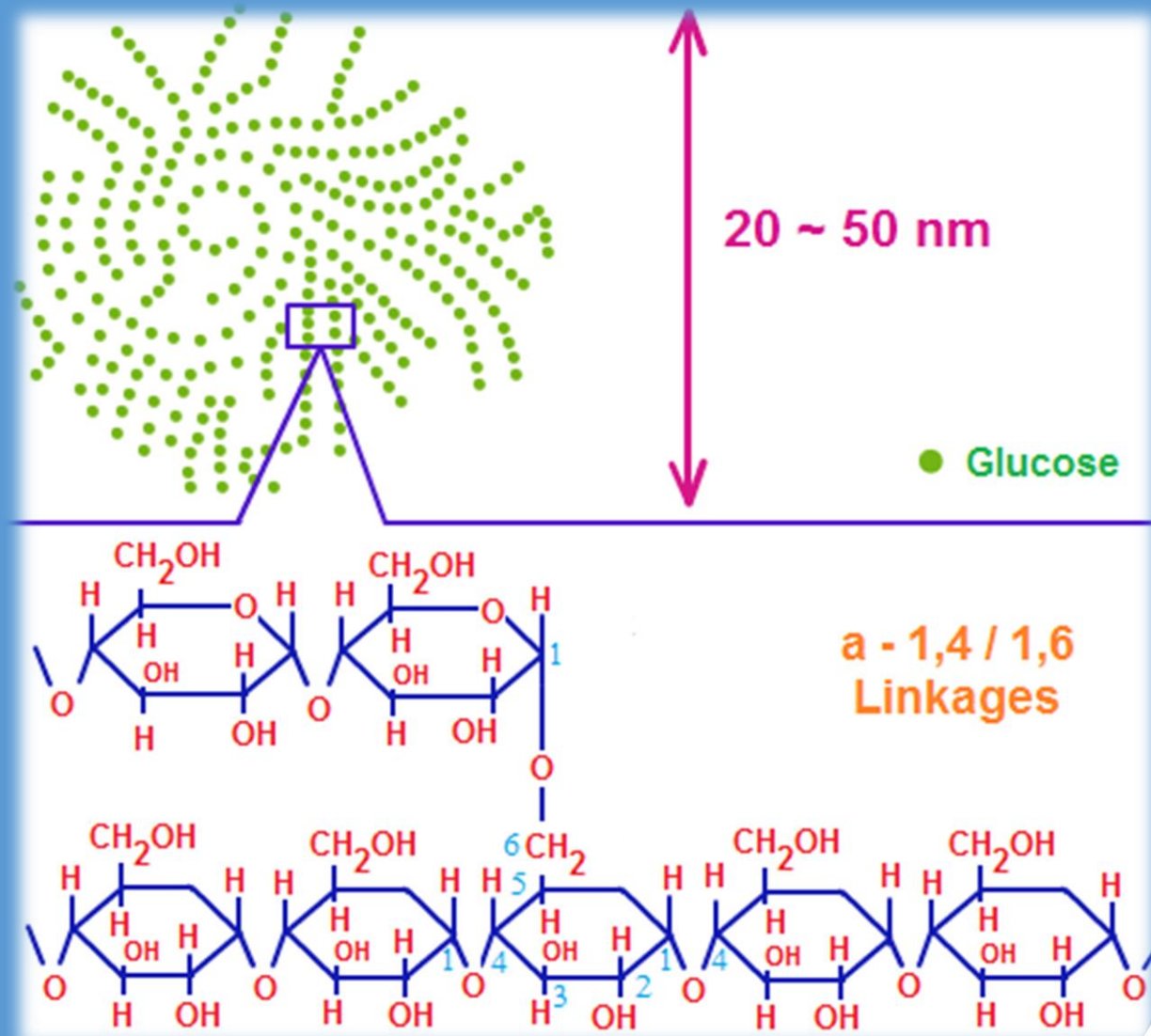


# گلیکوژن:

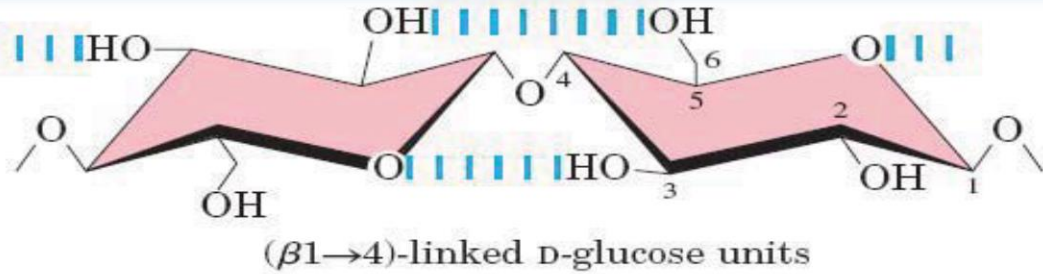


A

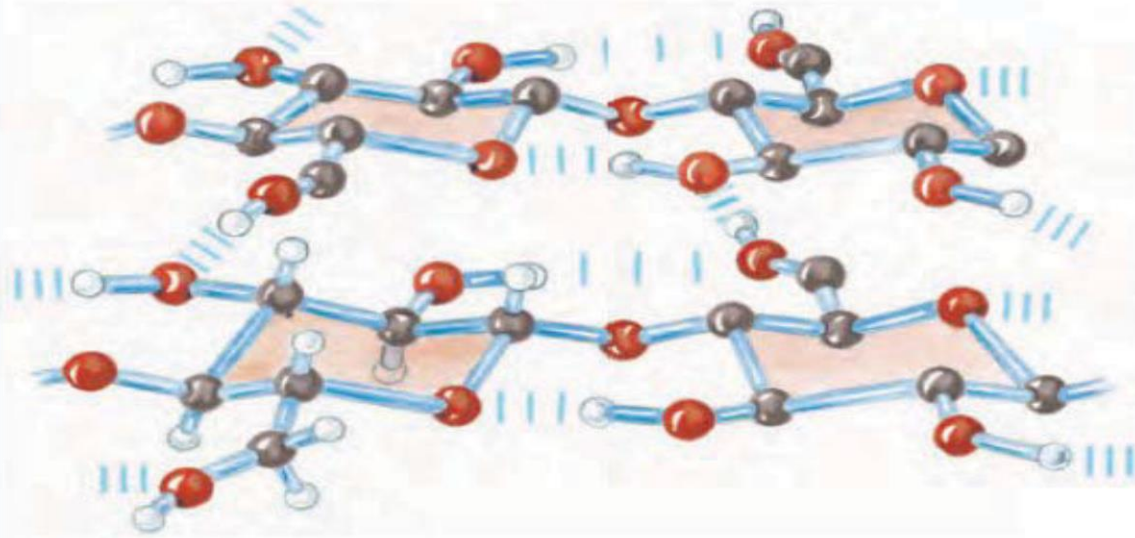
Figure 13-13. The glycogen molecule. **A:** General structure



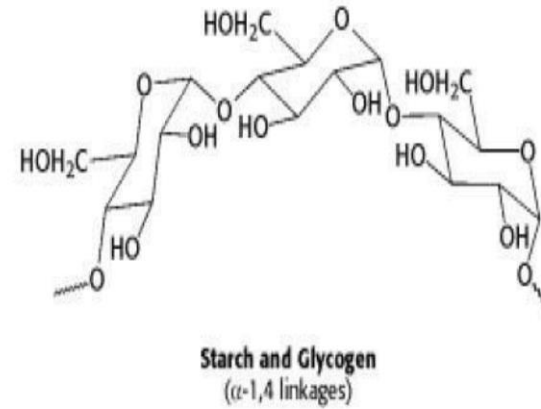
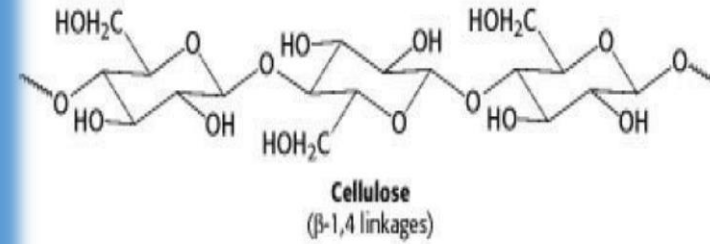
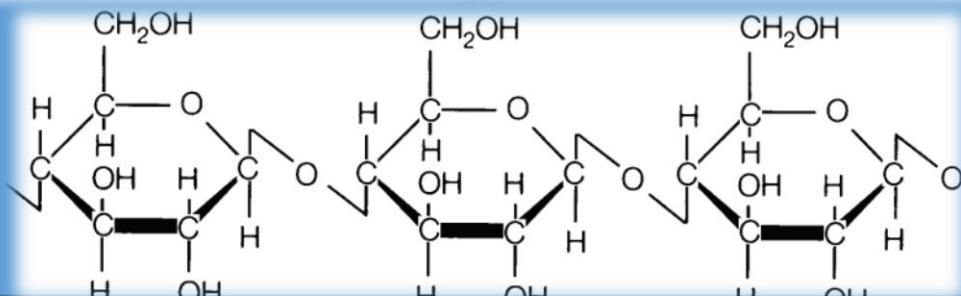
# سلولز:



(a)



(b)



**Figure 11.14. Glycosidic Bonds Determine Polysaccharide Structure.** The  $\beta$ -1,4 linkages favor straight chains, which are optimal for structural purposes. The  $\alpha$ -1,4 linkages favor bent structures, which are more suitable for storage.



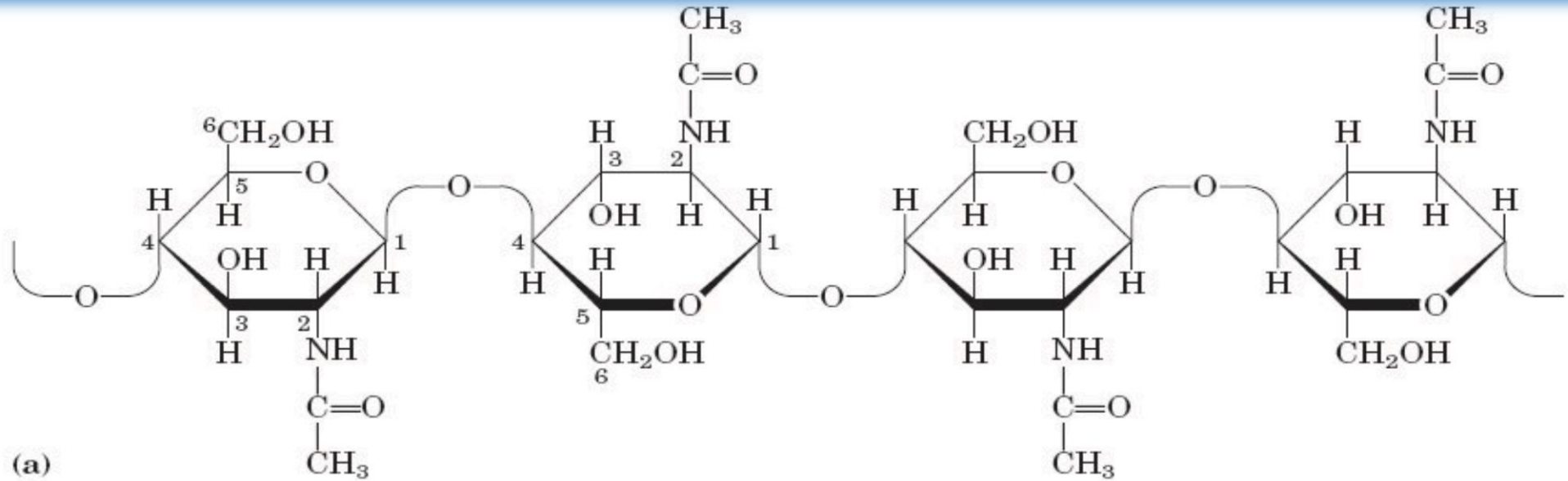
## سلولز:



**FIGURE 7-17** Cellulose breakdown by wood fungi. A wood fungus growing on an oak log. All wood fungi have the enzyme cellulase, which breaks the ( $\beta$ 1 $\rightarrow$ 4) glycosidic bonds in cellulose, such that wood is a source of metabolizable sugar (glucose) for the fungus. The only vertebrates able to use cellulose as food are cattle and other ruminants (sheep, goats, camels, giraffes). The extra stomach compartment (rumen) of a ruminant teems with bacteria and protists that secrete cellulase.



# کیتین:



**FIGURE 7-18 Chitin.** (a) A short segment of chitin, a homopolymer of *N*-acetyl-D-glucosamine units in ( $\beta 1 \rightarrow 4$ ) linkage. (b) A spotted June beetle (*Pellidnota punetata*), showing its surface armor (exoskeleton) of chitin.



(b)

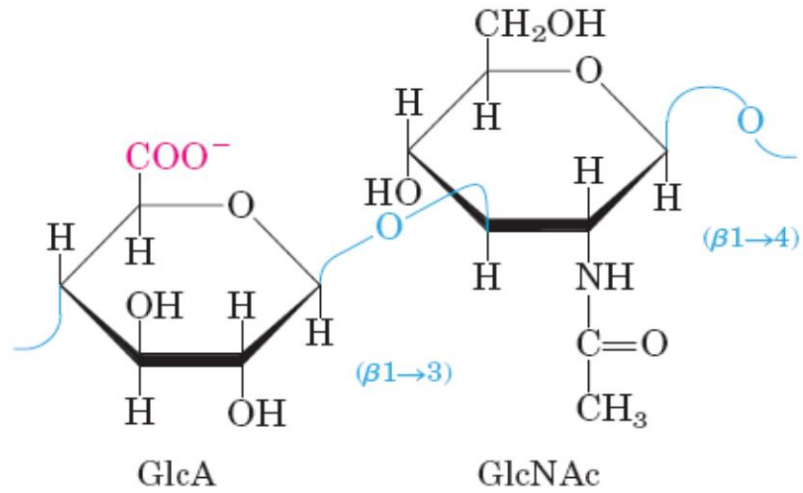
# گلیکوز آمینو گلیکان ها:

## Glycosaminoglycan

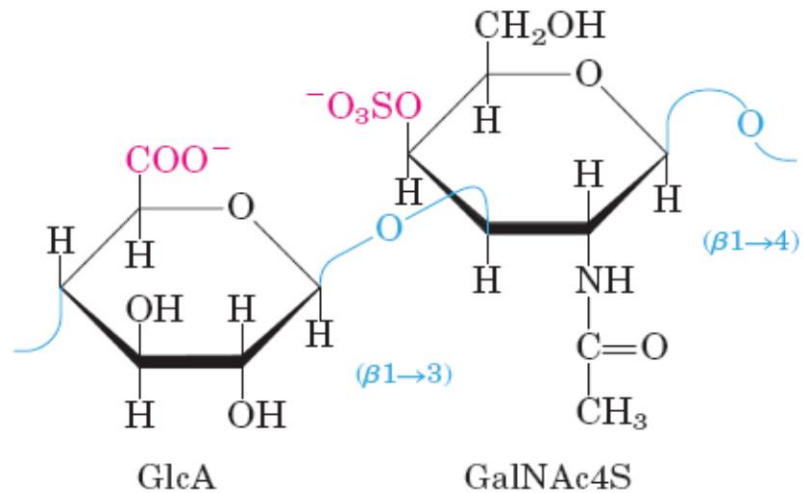
## Repeating disaccharide

Number of disaccharides per chain

Hyaluronate  
~50,000

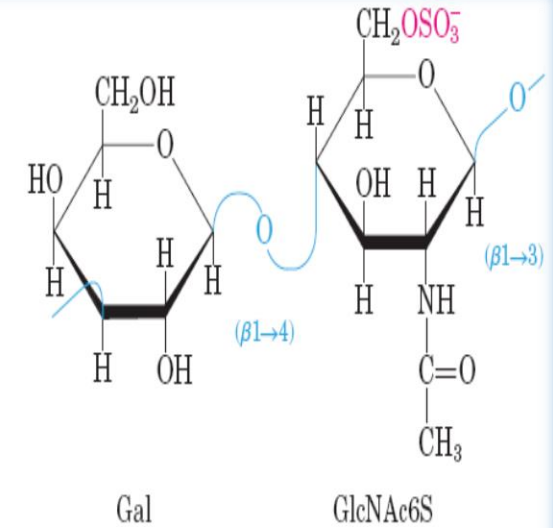


Chondroitin 4-sulfate  
20-60

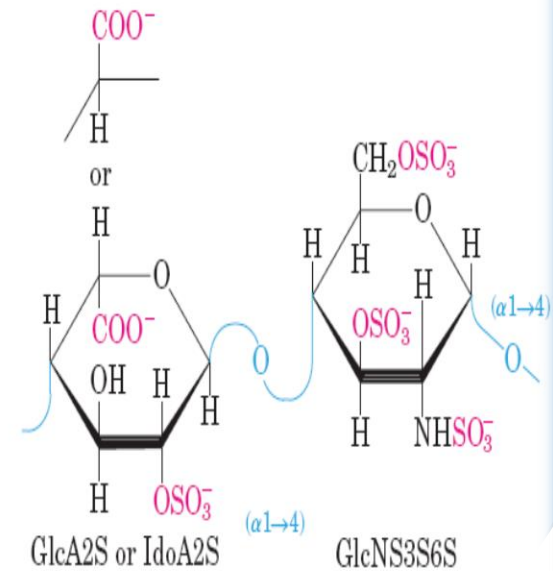


**FIGURE 7-24** Repeating units of some common glycosaminoglycans of extracellular matrix. The molecules are copolymers of alternating uronic acid and amino sugar residues, with sulfate esters in any of several positions. The ionized carboxylate and sulfate groups (red) give these polymers their characteristic high negative charge. Heparin contains primarily iduronic acid (IdoA) and a smaller proportion of glucuronic acid (GlcA), and is generally highly sulfated and heterogeneous in length. Heparan sulfate (not shown) is similar to heparin but has a higher proportion of GlcA and fewer sulfate groups, arranged in a less regular pattern.

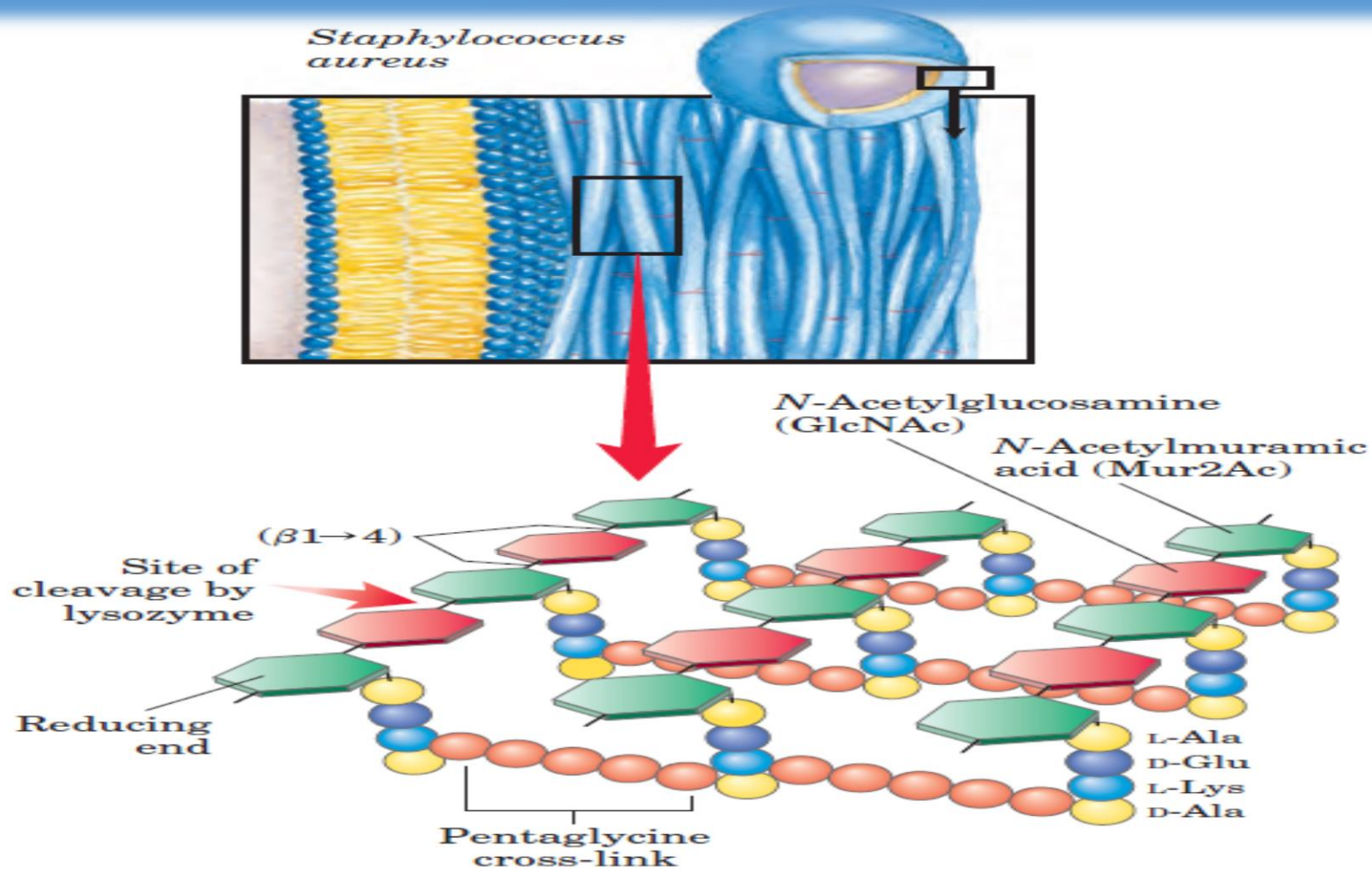
Keratan sulfate  
~25



Heparin  
15-90



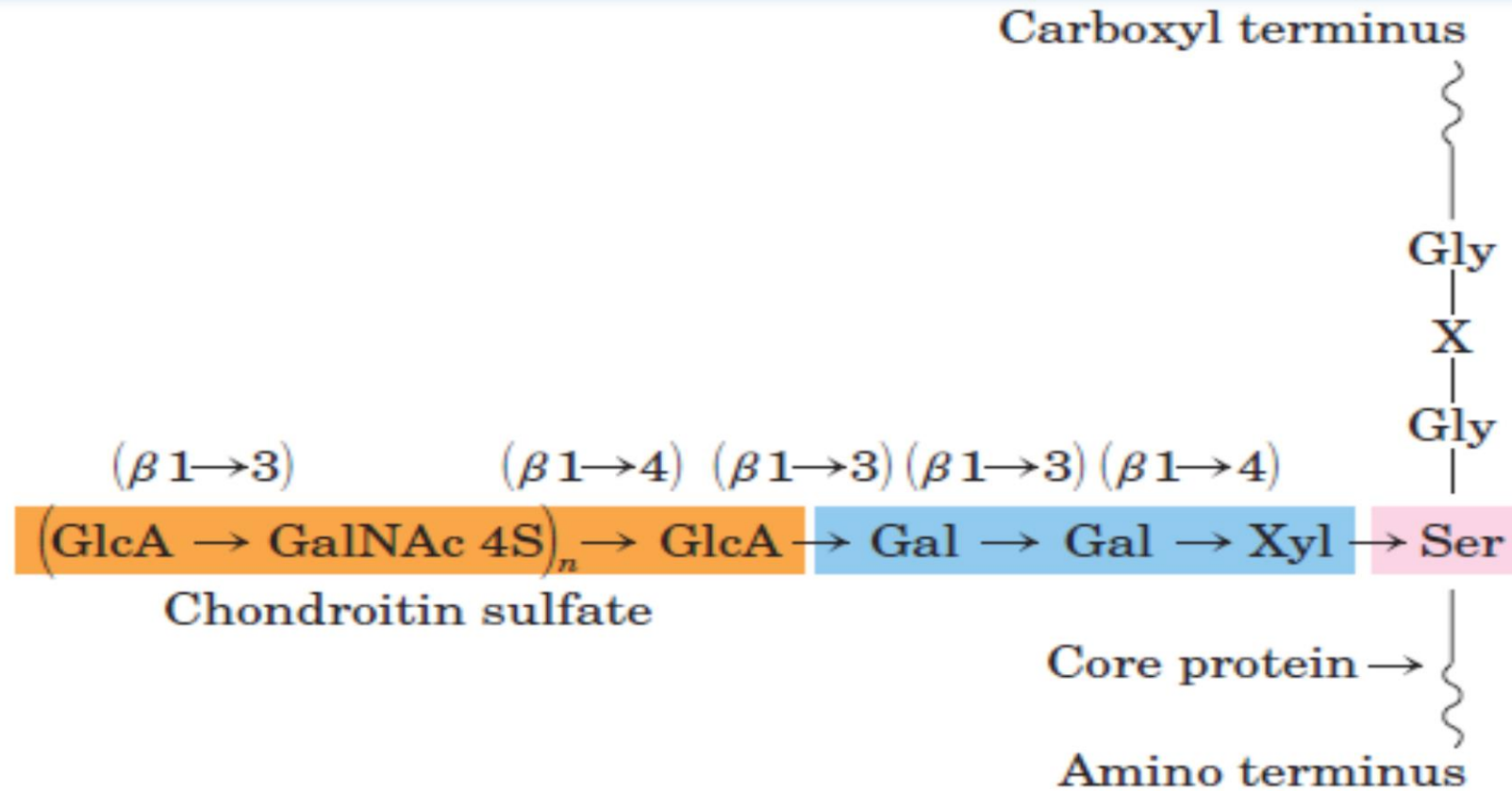
# پپتید گلیکان:



**FIGURE 7-22 Peptidoglycan.** Shown here is the peptidoglycan of the cell wall of *Staphylococcus aureus*, a gram-positive bacterium. Peptides (strings of colored spheres) covalently link *N*-acetylmuramic acid residues in neighboring polysaccharide chains. Note the mixture of L and D amino acids in the peptides. Gram-positive bacteria have a pentaglycine chain in the cross-link. Gram-negative bacteria, such as *E. coli*, lack the pentaglycine; instead, the terminal D-Ala residue of one tetrapeptide is attached directly to a neighboring tetrapeptide through either L-Lys or a lysine-like amino acid, diaminopimelic acid.

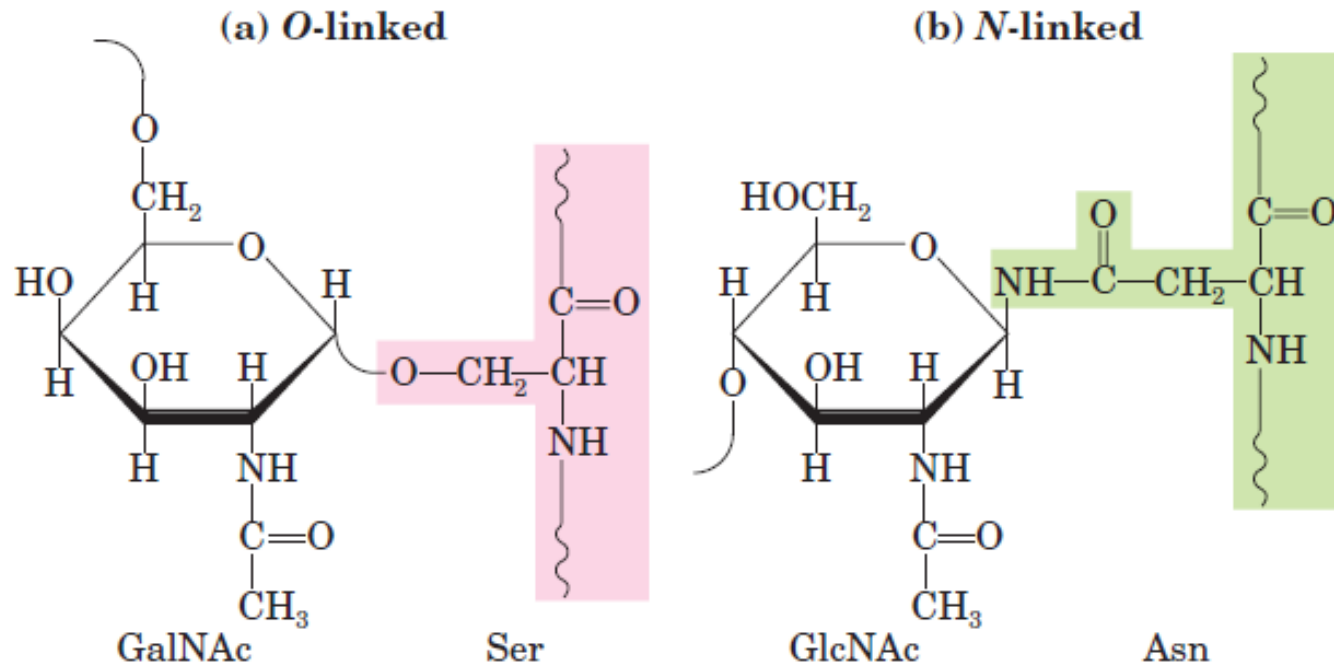


# پروتئو گلیکان:



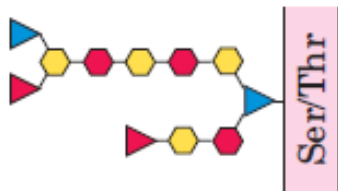
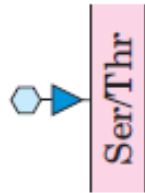
**FIGURE 7-26** Proteoglycan structure, showing the trisaccharide bridge. A typical trisaccharide linker (blue) connects a glycosaminoglycan—in this case chondroitin sulfate (orange)—to a Ser residue (red) in the core protein. The xylose residue at the reducing end of the linker is joined by its anomeric carbon to the hydroxyl of the Ser residue.

# گلیکوپروتین ہا:

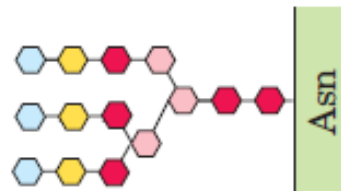
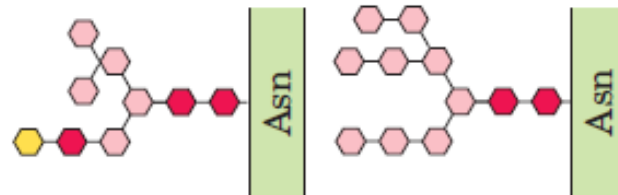


**FIGURE 7-31** Oligosaccharide linkages in glycoproteins. (a) *O*-linked oligosaccharides have a glycosidic bond to the hydroxyl group of Ser or Thr residues (shaded pink), illustrated here with GalNAc as the sugar at the reducing end of the oligosaccharide. One simple chain and one complex chain are shown. (b) *N*-linked oligosaccharides have an *N*-glycosyl bond to the amide nitrogen of an Asn residue (shaded green), illustrated here with GlcNAc as the terminal sugar. Three common types of oligosaccharide chains that are *N*-linked in glycoproteins are shown. A complete description of oligosaccharide structure requires specification of the position and stereochemistry ( $\alpha$  or  $\beta$ ) of each glycosidic linkage.

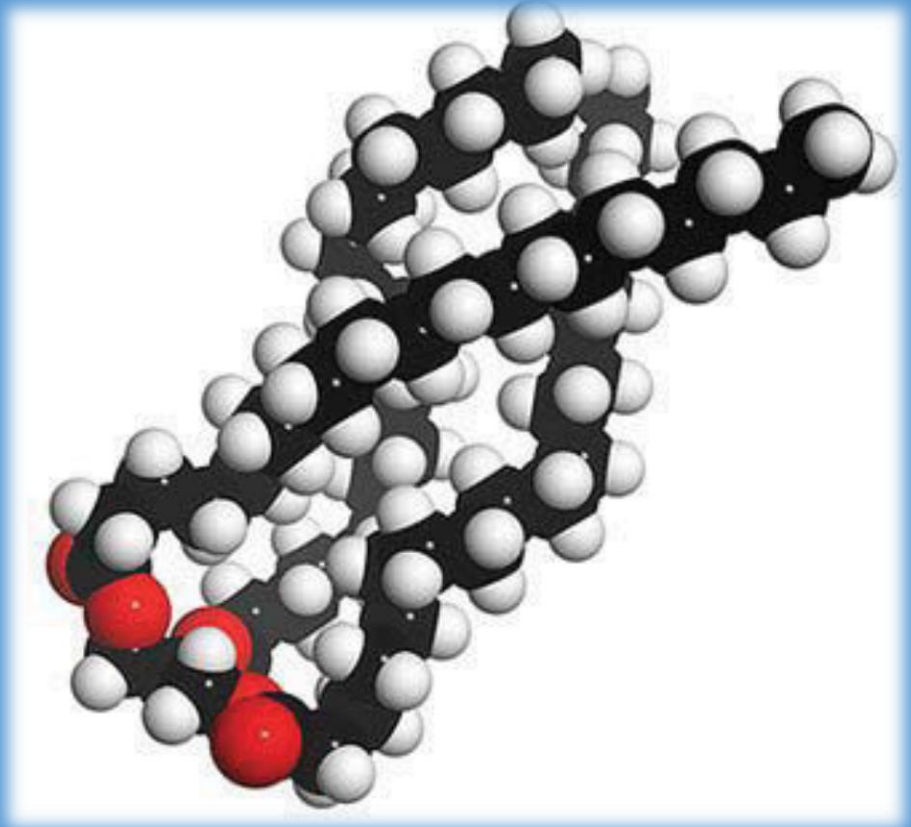
Examples:



Examples:



- GlcNAc
- Man
- Gal
- Neu5Ac
- ▼ Fuc
- ▼ GalNAc

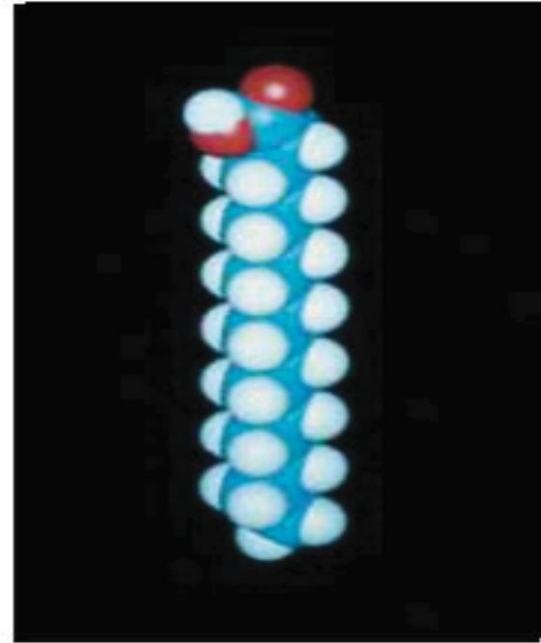
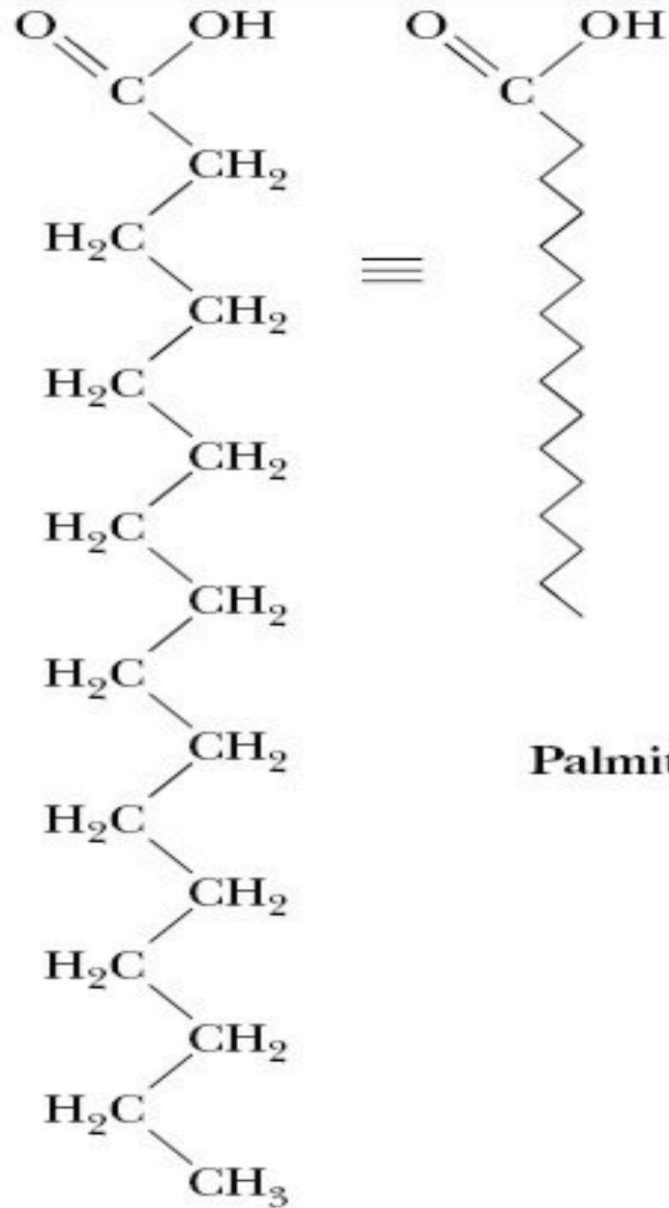


## لیپیدها: ✓

- اهمیت
- ویژگی ها
- ساختمان شیمیایی

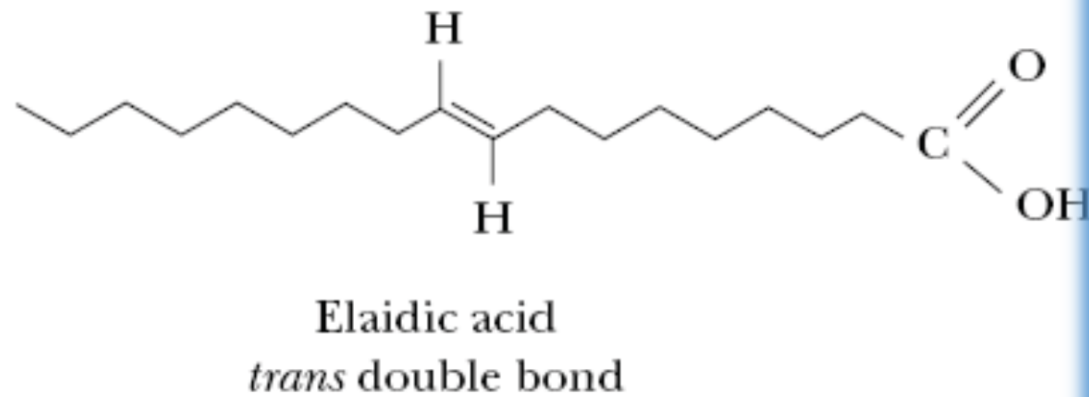
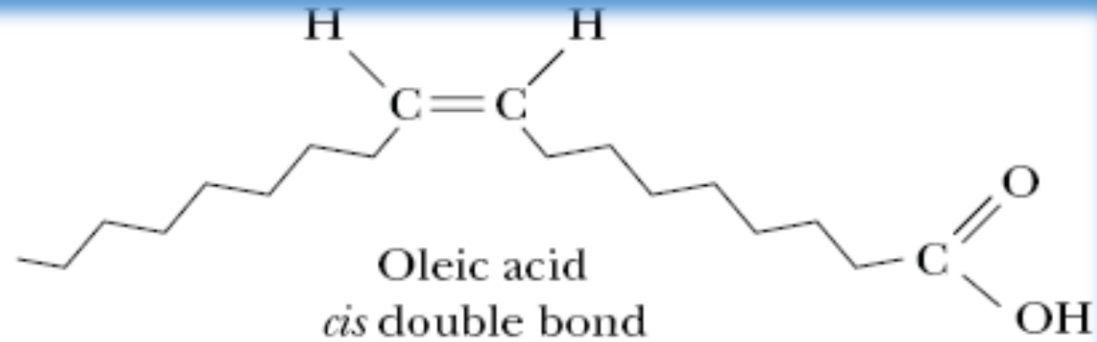


# اسیدهای چرب:



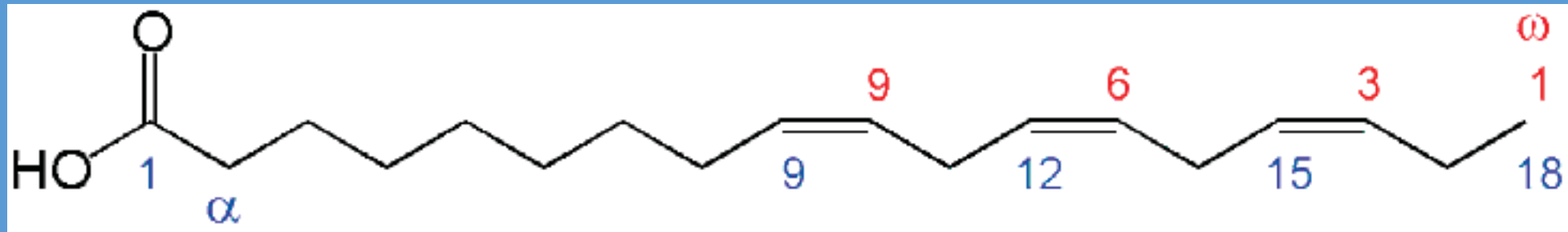
Palmitic acid

# ایزومرهای اسیدهای چرب غیر اشباع:



Structure of *cis* and *trans* monounsaturated C<sub>18</sub> fatty acids.

# ایزومرهای اسیدهای چرب غیر اشباع:



18:3( $\Delta$ 9,12, 15)

18:3( $\omega$ 3, 6,9)

## اسیدهای چرب مهم:

16:1( $\Delta$ 9)

اسید پالمیتولئیک

14:0

اسید میریستیک

18:1( $\Delta$ 9)

اسید اولئیک

16:0

اسید پالمیتیک

18:2( $\Delta$ 9,12)

اسید لینولئیک

18:0

اسید استئاریک

18:3( $\Delta$ 9,12, 15)

اسید آلفا لینولنیک

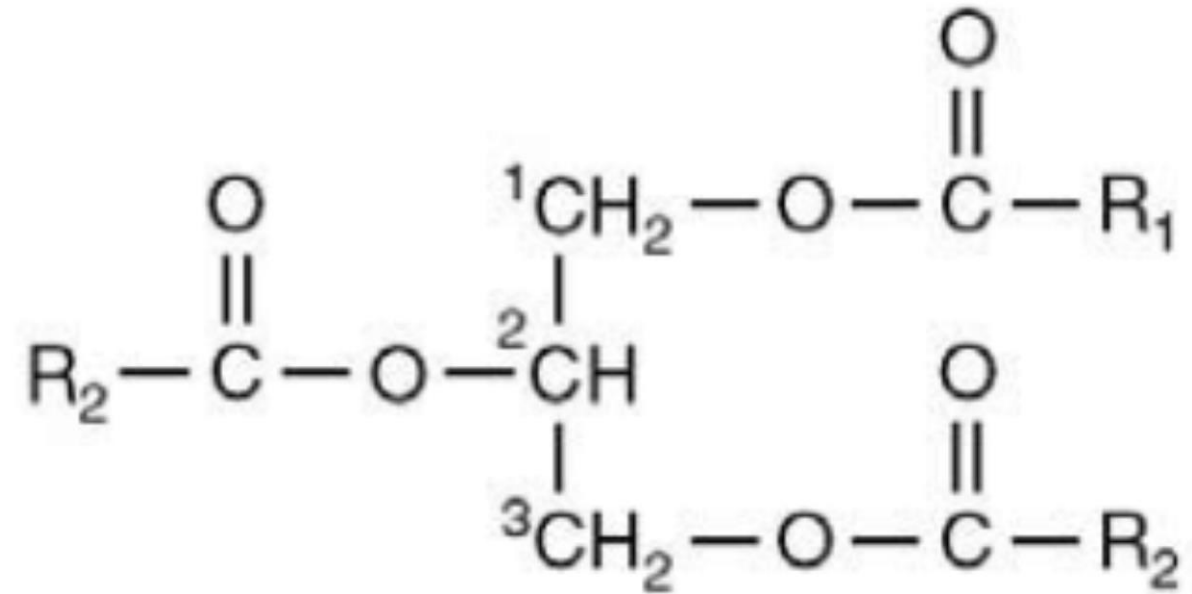
18:3( $\Delta$ 6, 9, 12)

اسید گاما لینولنیک

20:4( $\Delta$ 5, 8, 11, 14)

اسید آراشیدونیک

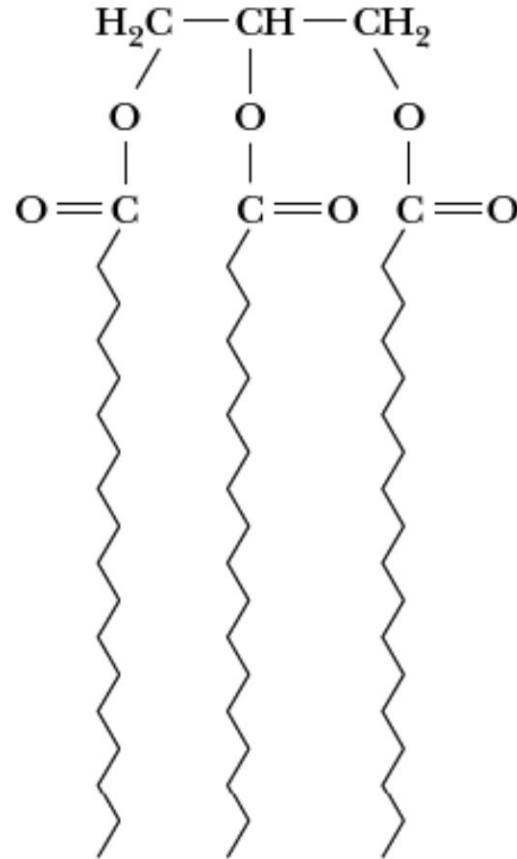
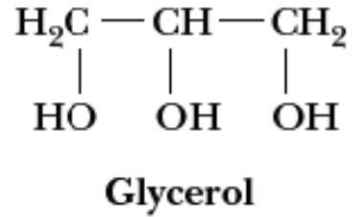
## تری گلیسیریدها:



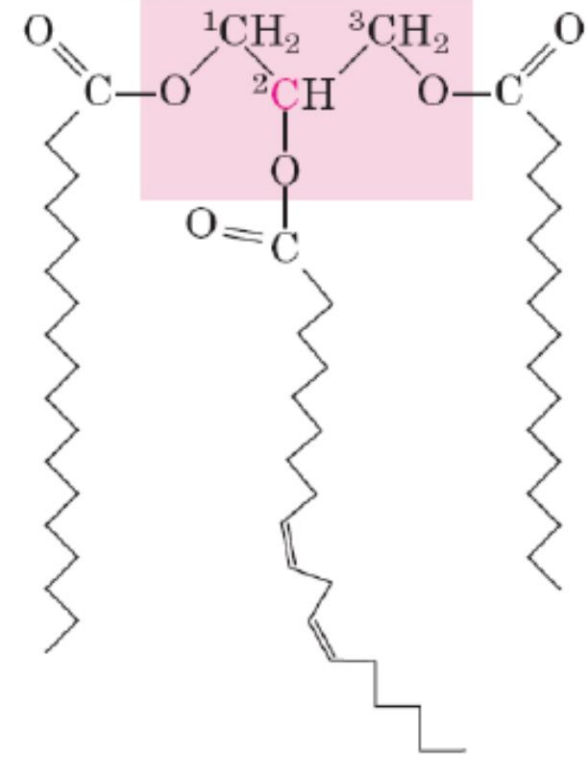
**Figure 14-6.** Triacylglycerol.



# انواع تری گلیسیریدها:

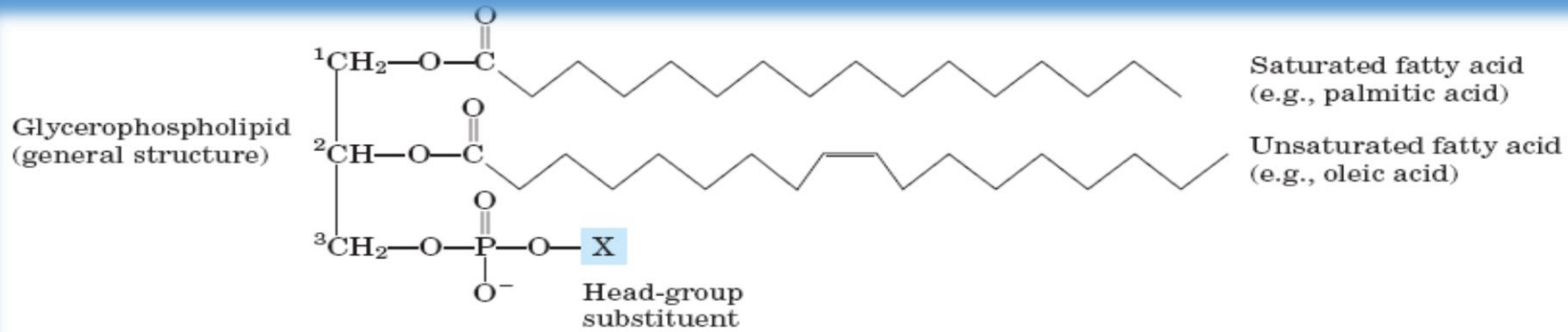


**Tristearin**  
(a simple triacylglycerol)



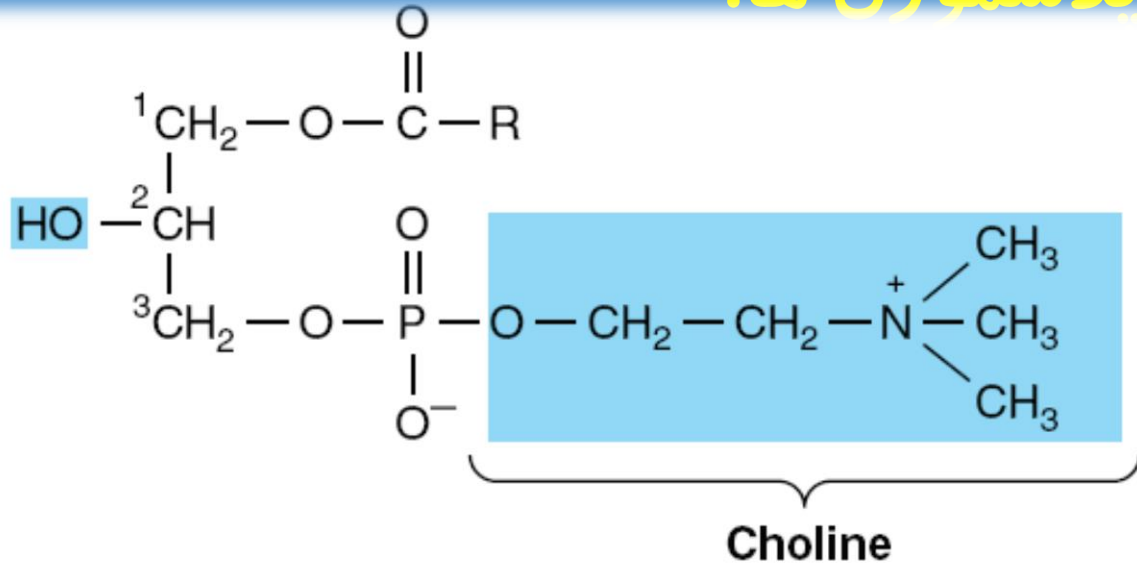
1-Stearoyl, 2-linoleoyl, 3-palmitoyl glycerol,  
a mixed triacylglycerol

# فسفولیپیدها:

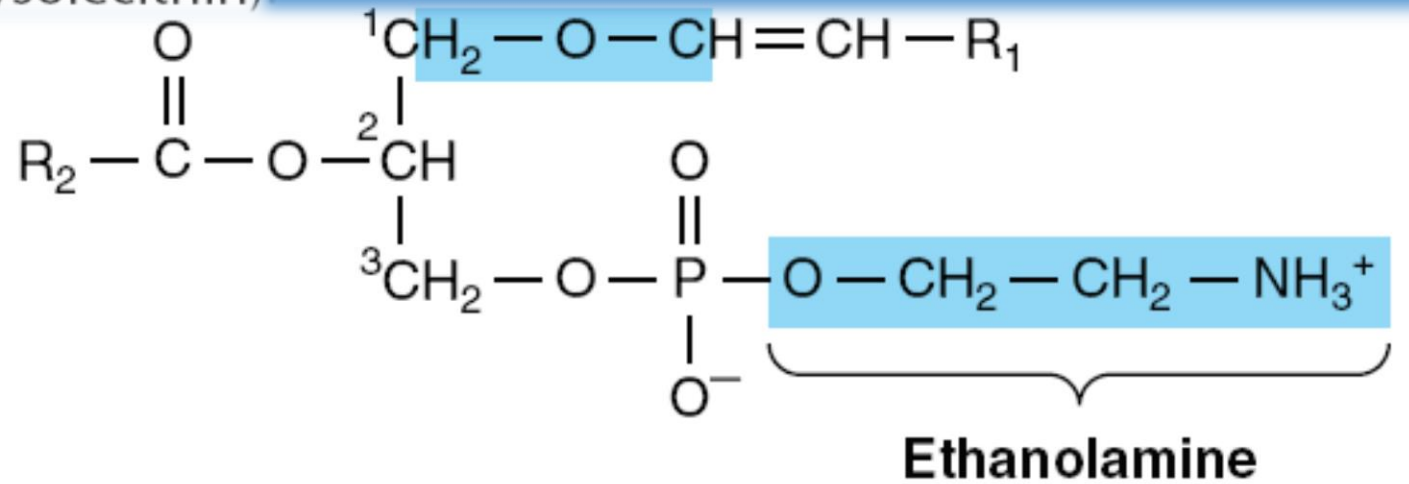


Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	—H	-1
Phosphatidylethanolamine	Ethanolamine	—CH <sub>2</sub> —CH <sub>2</sub> —NH <sub>3</sub> <sup>+</sup>	0
Phosphatidylcholine	Choline	—CH <sub>2</sub> —CH <sub>2</sub> —N <sup>+</sup> (CH <sub>3</sub> ) <sub>3</sub>	0
Phosphatidylserine	Serine	—CH <sub>2</sub> —CH(NH <sub>3</sub> <sup>+</sup> )—COO <sup>-</sup>	-1
Phosphatidylglycerol	Glycerol	—CH <sub>2</sub> —CH(OH)—CH <sub>2</sub> —OH	-1
Phosphatidylinositol 4,5-bisphosphate	<i>myo</i> -Inositol 4,5-bisphosphate		-4

## لیزو فسفولیپیدها و پلاسموژن ها:



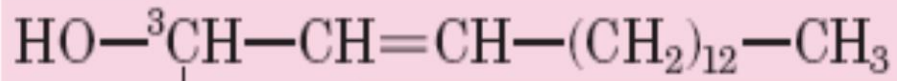
**Figure 14-9.** Lysophosphatidylcholine (lysolecithin)



**Figure 14-10.** Plasmalogen.

# اسفینگولپیدھا:

Sphingosine



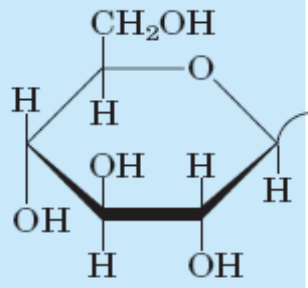
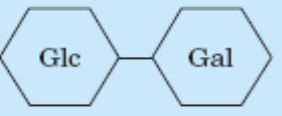
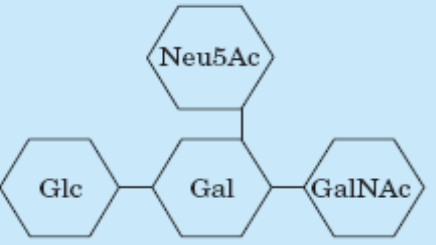
Fatty acid

Sphingolipid  
(general  
structure)

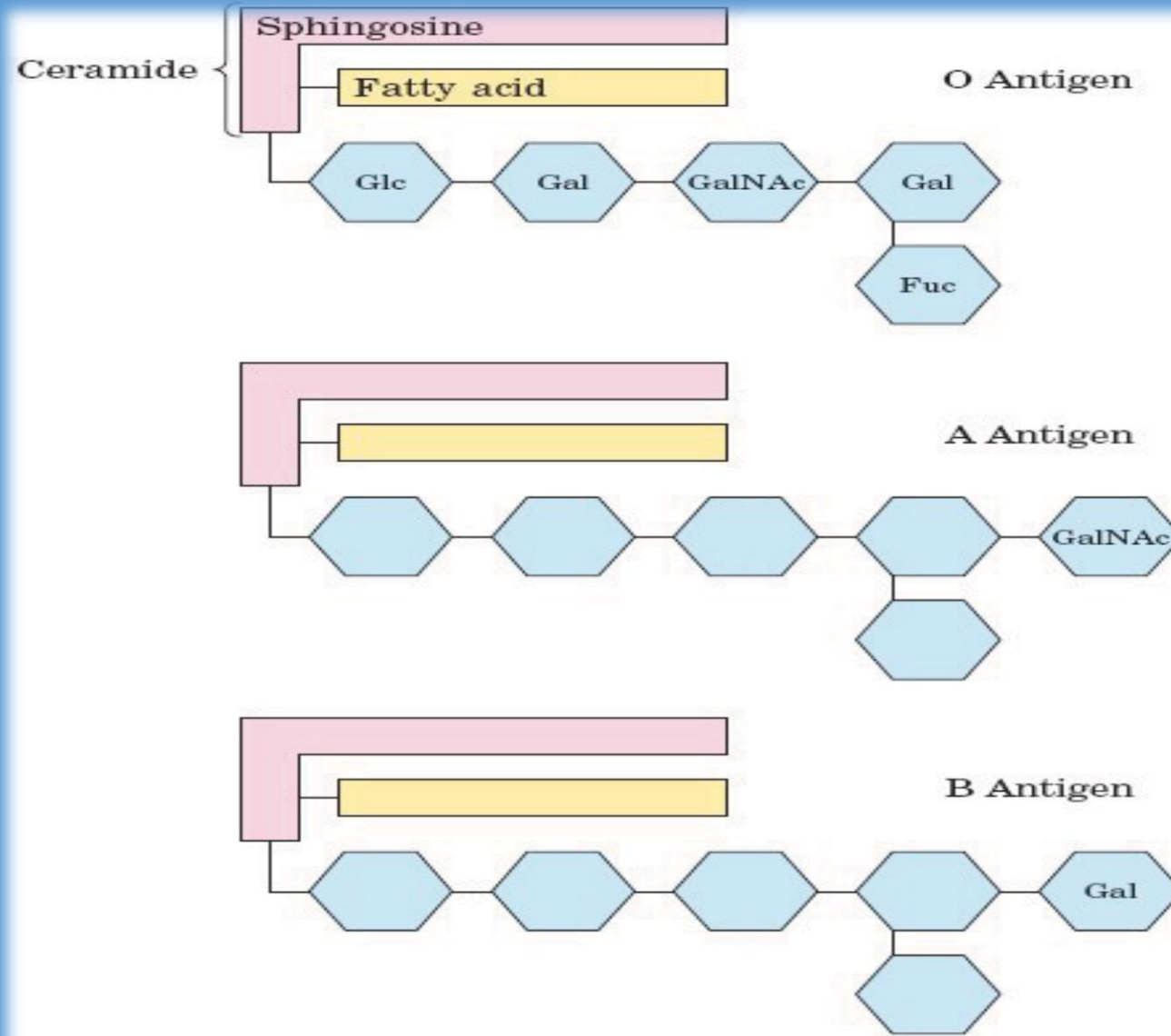




# انواع اسفینگولیپیدھا:

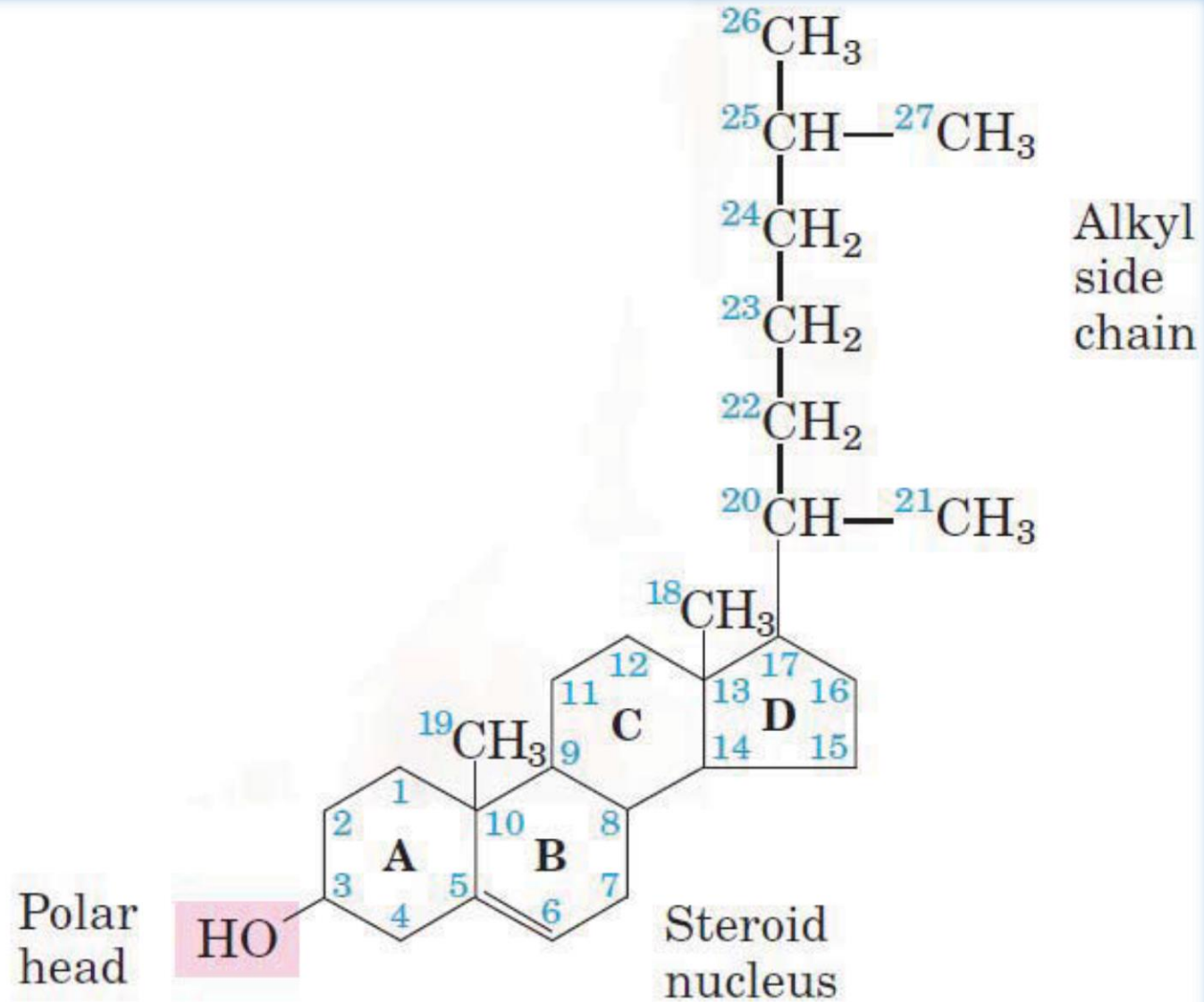
Name of sphingolipid	Name of X	Formula of X
Ceramide	—	— H
Sphingomyelin	Phosphocholine	$\begin{array}{c} \text{O} \\ \parallel \\ \text{— P — O — CH}_2\text{ — CH}_2\text{ — N}^+(\text{CH}_3)_3 \\   \\ \text{O}^- \end{array}$
Neutral glycolipids Glucosylcerebroside	Glucose	
Lactosylceramide (a globoside)	Di-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

# ارتباط اسفینگولیپیدها و گروه های خونی:



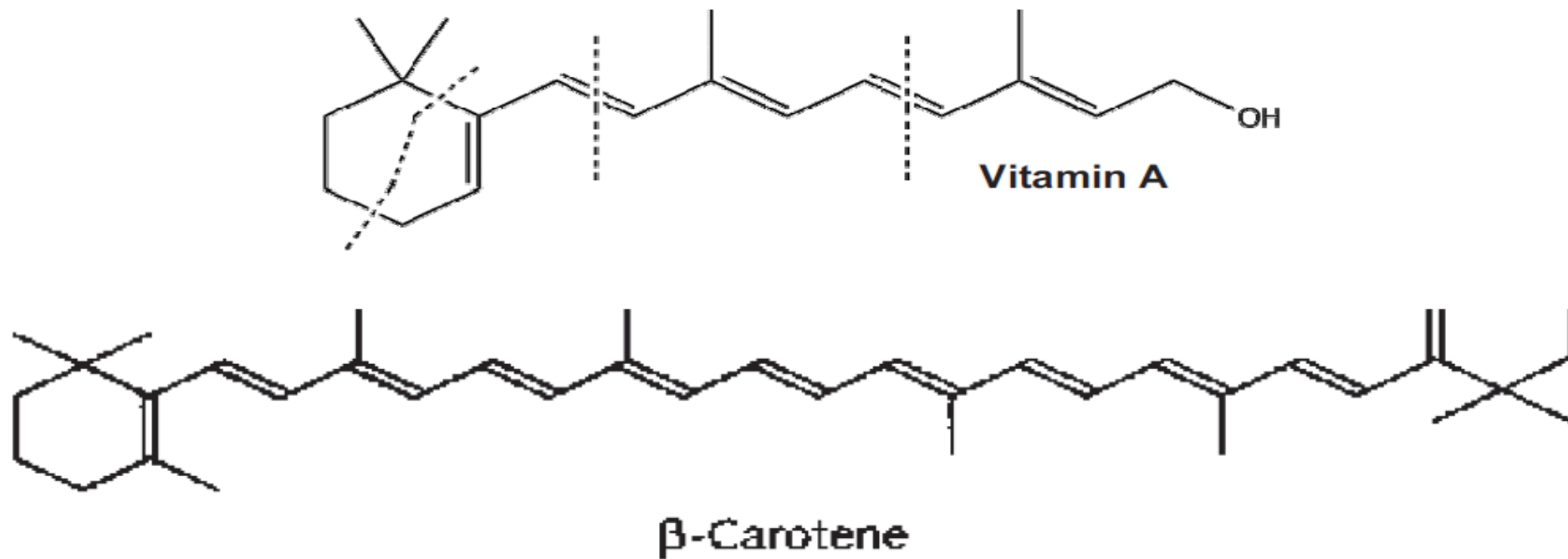
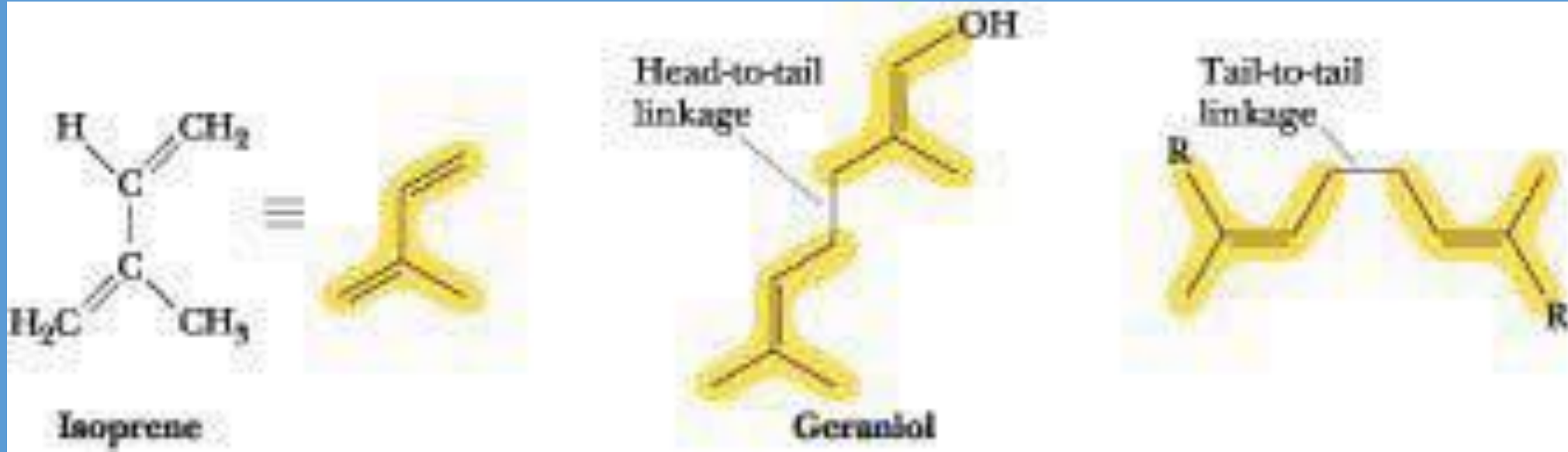
**FIGURE 10-14** Glycosphingolipids as determinants of blood groups. The human blood groups (O, A, B) are determined in part by the oligosaccharide head groups (blue) of these glycosphingolipids.

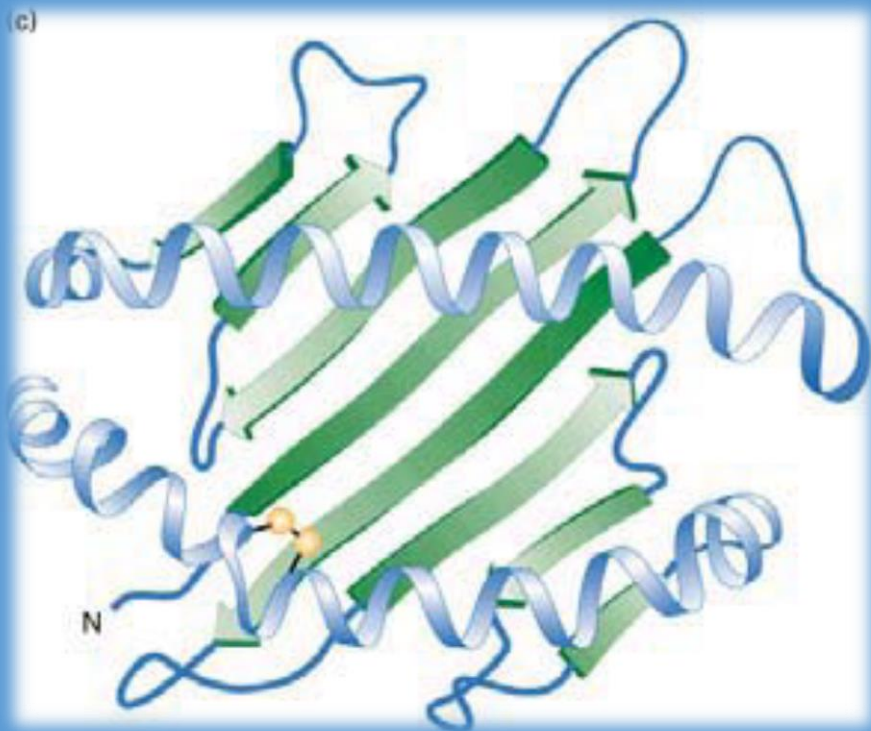
# استرول ها:



**FIGURE 10-16** Cholesterol.

# ترپن ہا:





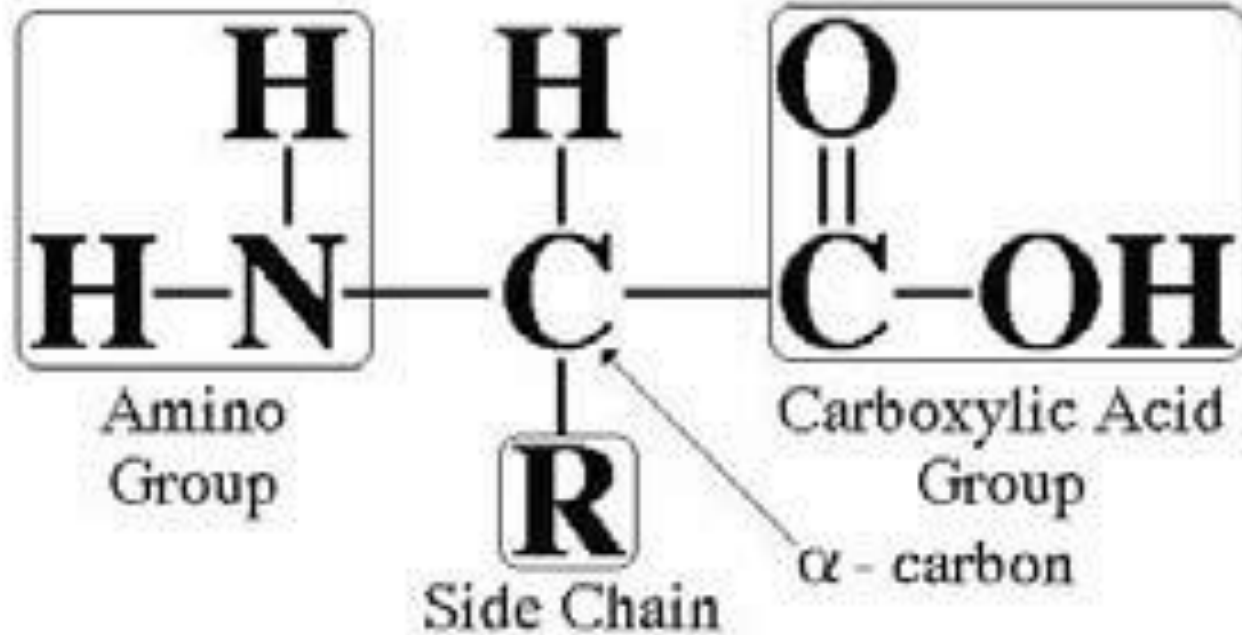
# پروتئین‌ها: ✓

- اهمیت
- ویژگی‌ها
- ساختمان شیمیایی



# آمینواسیدها:

## Amino Acid Structure

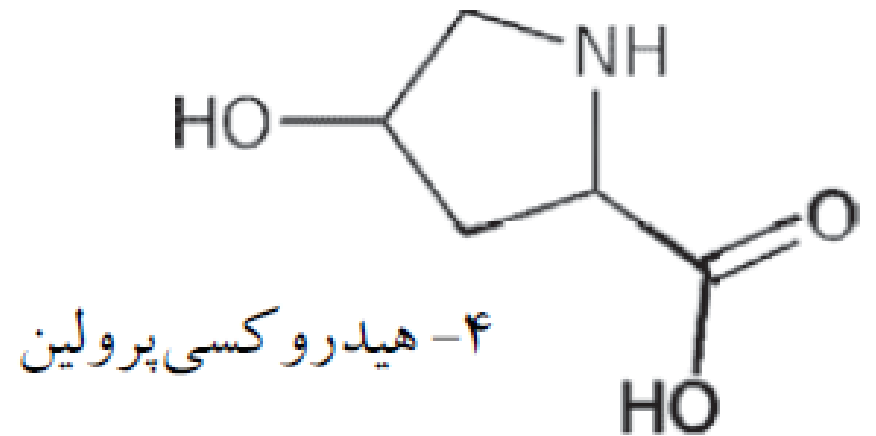
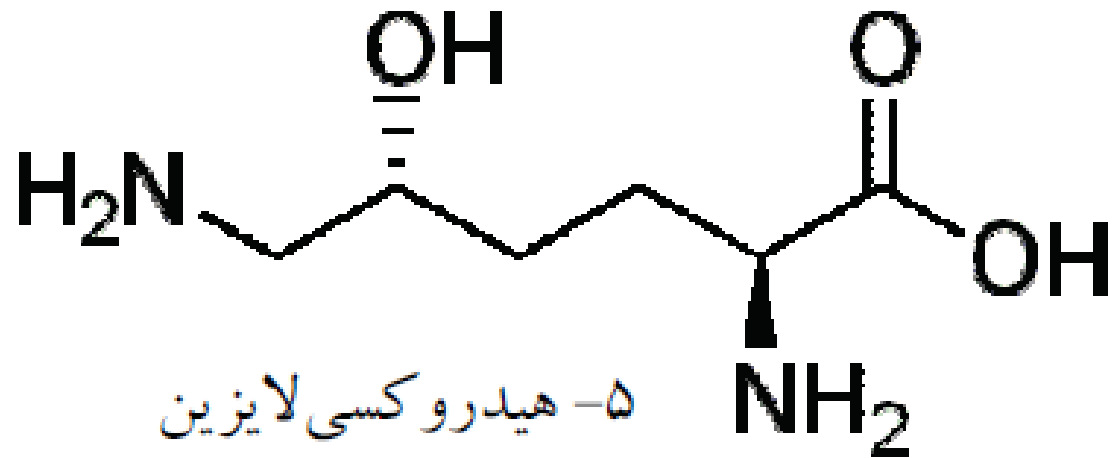


# آمینواسیدها:

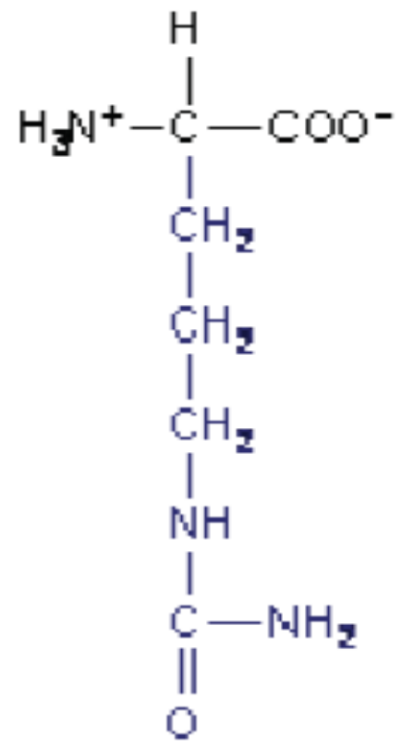
**TABLE 3-1** Properties and Conventions Associated with the Common Amino Acids Found in Proteins

Amino acid	Abbreviation/ symbol	$M_r$	$pK_a$ values			$pI$	Hydropathy index*	Occurrence in proteins (%) <sup>†</sup>
			$pK_1$ (—COOH)	$pK_2$ (—NH <sub>3</sub> <sup>+</sup> )	$pK_R$ (R group)			
<b>Nonpolar, aliphatic R groups</b>								
Glycine	Gly G	75	2.34	9.60		5.97	-0.4	7.2
Alanine	Ala A	89	2.34	9.69		6.01	1.8	7.8
Proline	Pro P	115	1.99	10.96		6.48	1.6	5.2
Valine	Val V	117	2.32	9.62		5.97	4.2	6.6
Leucine	Leu L	131	2.36	9.60		5.98	3.8	9.1
Isoleucine	Ile I	131	2.36	9.68		6.02	4.5	5.3
Methionine	Met M	149	2.28	9.21		5.74	1.9	2.3
<b>Aromatic R groups</b>								
Phenylalanine	Phe F	165	1.83	9.13		5.48	2.8	3.9
Tyrosine	Tyr Y	181	2.20	9.11	10.07	5.66	-1.3	3.2
Tryptophan	Trp W	204	2.38	9.39		5.89	-0.9	1.4
<b>Polar, uncharged R groups</b>								
Serine	Ser S	105	2.21	9.15		5.68	-0.8	6.8
Threonine	Thr T	119	2.11	9.62		5.87	-0.7	5.9
Cysteine	Cys C	121	1.96	10.28	8.18	5.07	2.5	1.9
Asparagine	Asn N	132	2.02	8.80		5.41	-3.5	4.3
Glutamine	Gln Q	146	2.17	9.13		5.65	-3.5	4.2
<b>Positively charged R groups</b>								
Lysine	Lys K	146	2.18	8.95	10.53	9.74	-3.9	5.9
Histidine	His H	155	1.82	9.17	6.00	7.59	-3.2	2.3
Arginine	Arg R	174	2.17	9.04	12.48	10.76	-4.5	5.1
<b>Negatively charged R groups</b>								
Aspartate	Asp D	133	1.88	9.60	3.65	2.77	-3.5	5.3
Glutamate	Glu E	147	2.19	9.67	4.25	3.22	-3.5	6.3

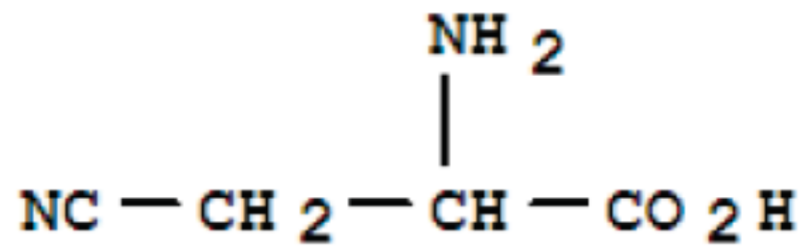
# آمینواسیدهای کمیاب پروتئینی:



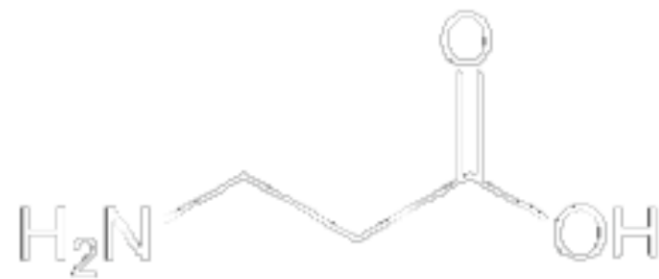
# آمینواسیدهای غیر پروتئینی:



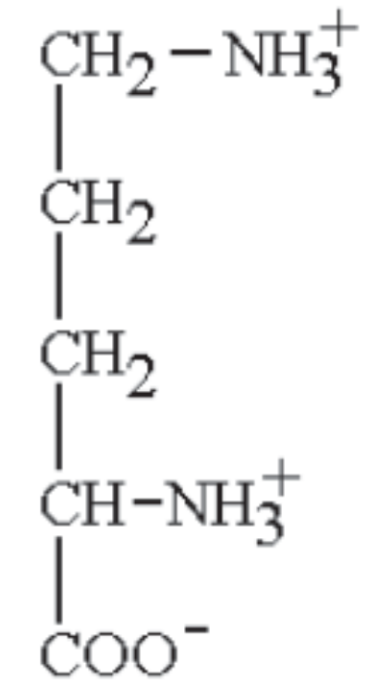
citrulline



β-آلانین

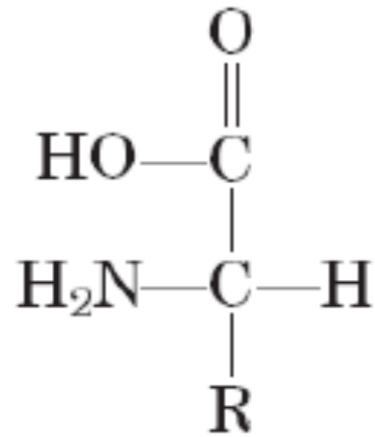


β-سیانوالانین

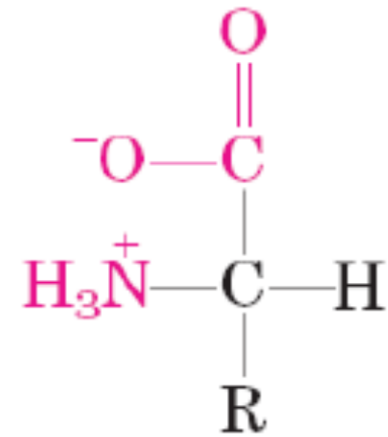


ornithine

## یونیزاسیون آمینواسیدها:



Nonionic  
form

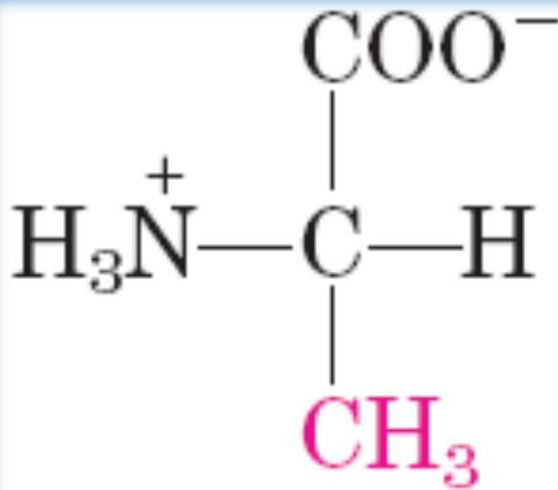


Zwitterionic  
form

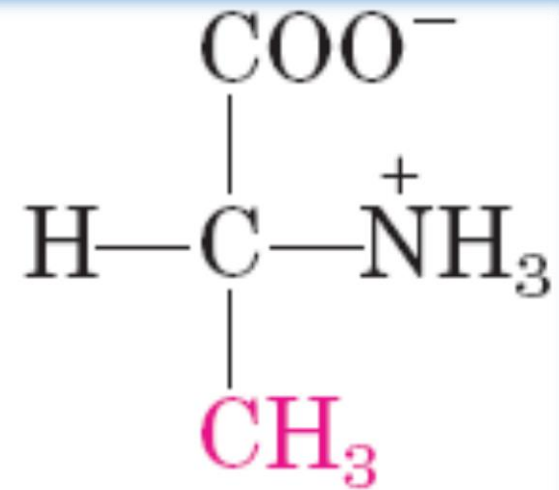
**FIGURE 3-9** Nonionic and **zwitterionic forms** of amino acids. The nonionic form does not occur in significant amounts in aqueous solutions. The zwitterion predominates at neutral pH.



## ایزومر فضایی در آمینواسیدها:



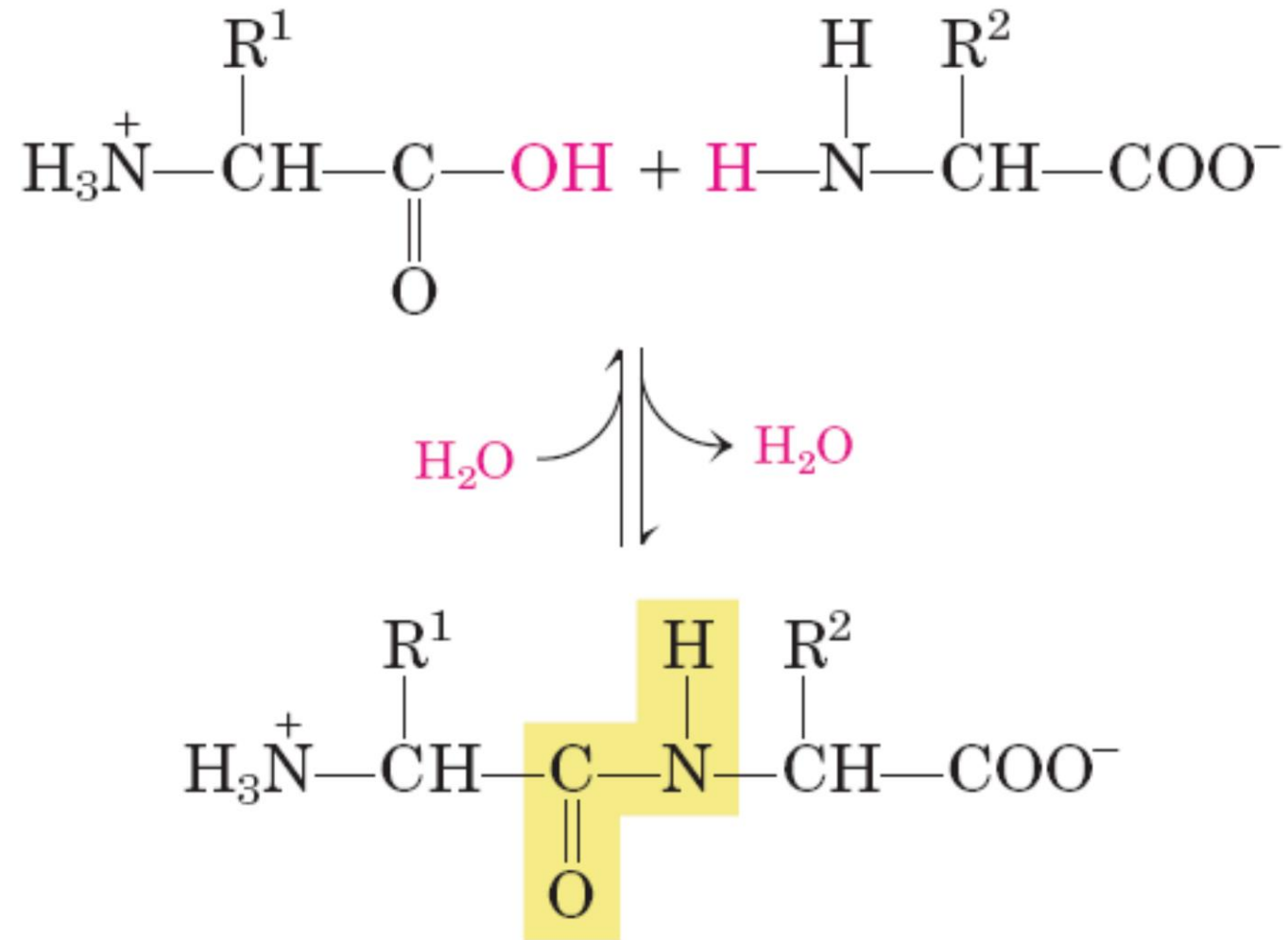
L-Alanine



D-Alanine

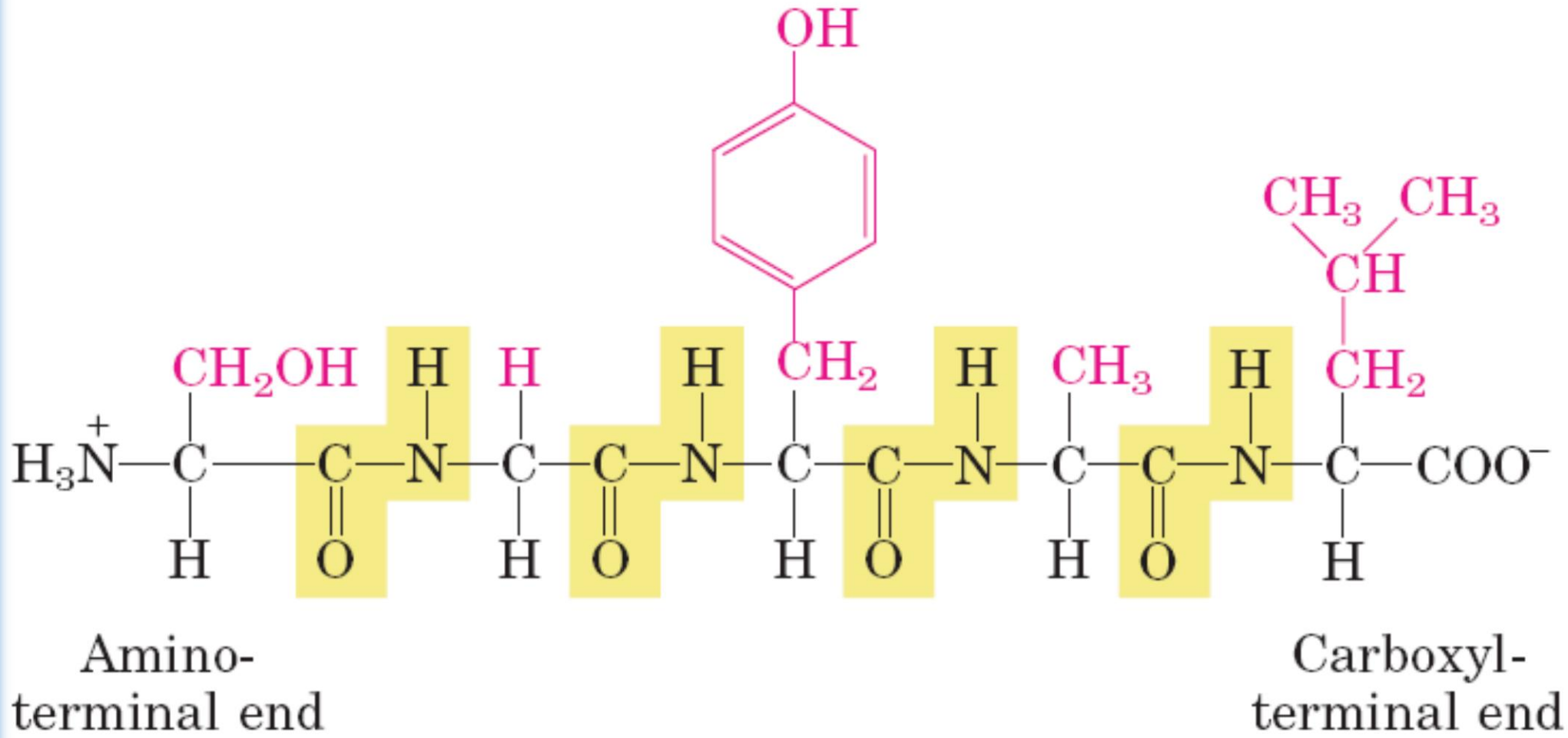
**Stereoisomerism in  $\alpha$ -amino acids.**

## پیوند پپتیدی:

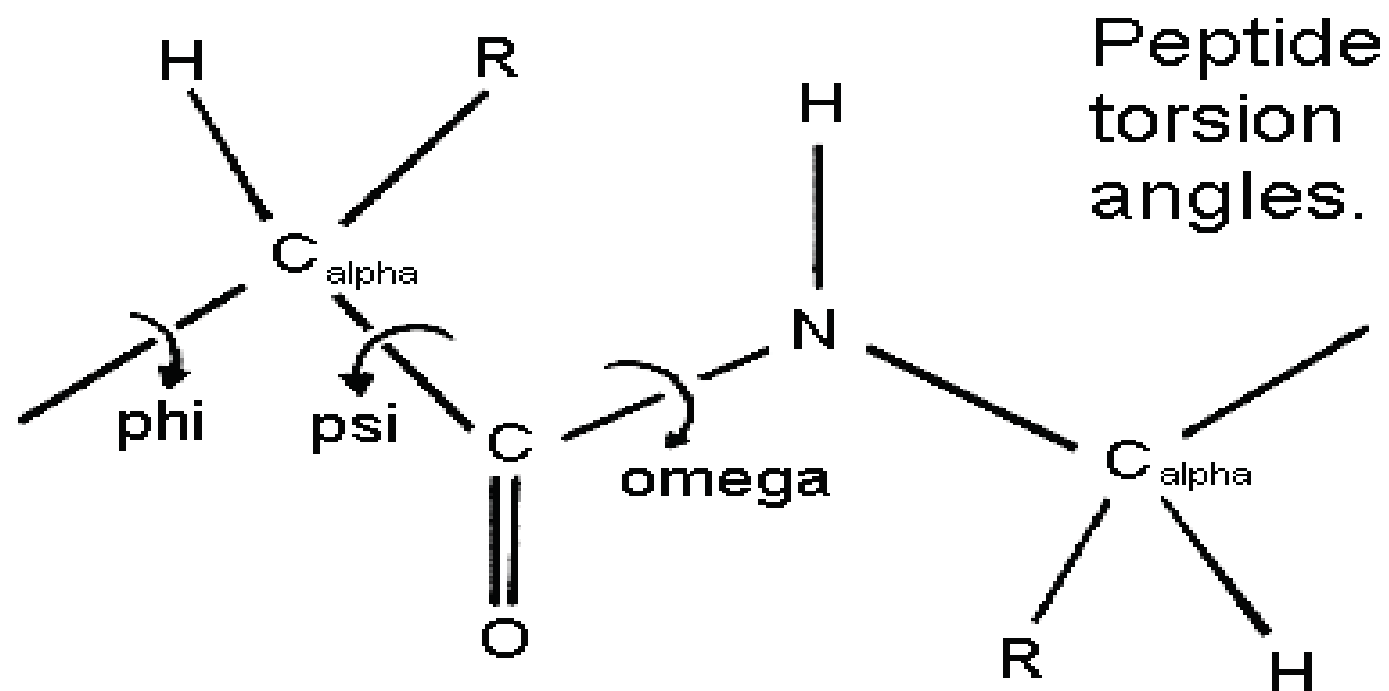
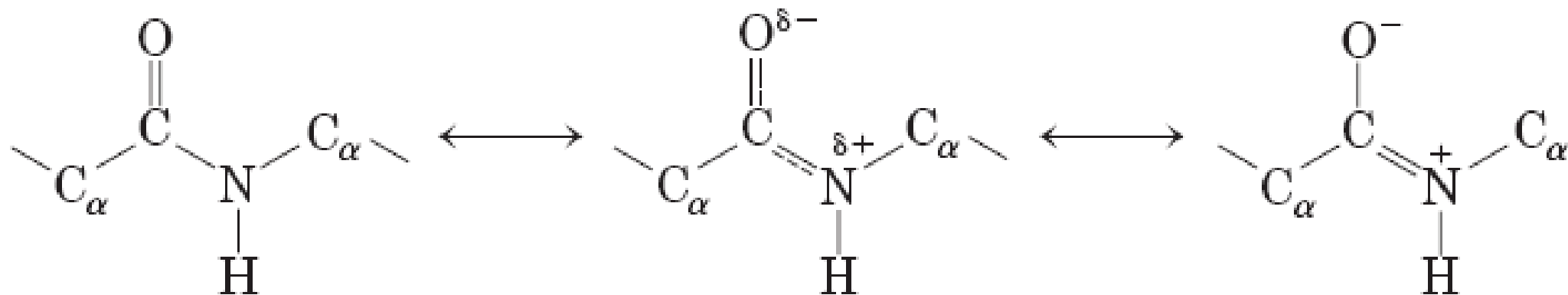


**FIGURE 3-13** Formation of a peptide bond by condensation.

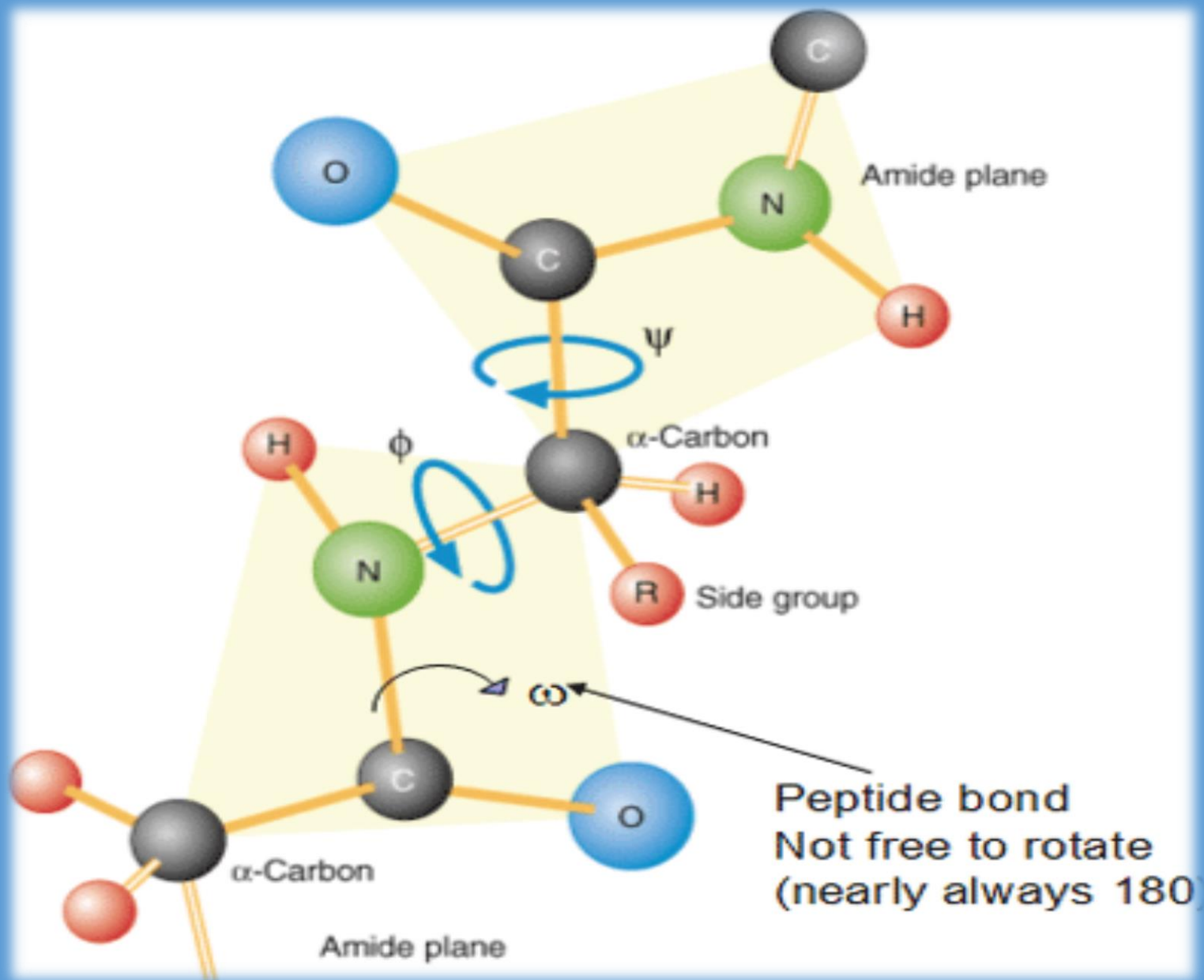
# ساختمان زنجیره پلی پپتید (پروتئین):



# انواع پیوندها در زنجیره پپتیدی:



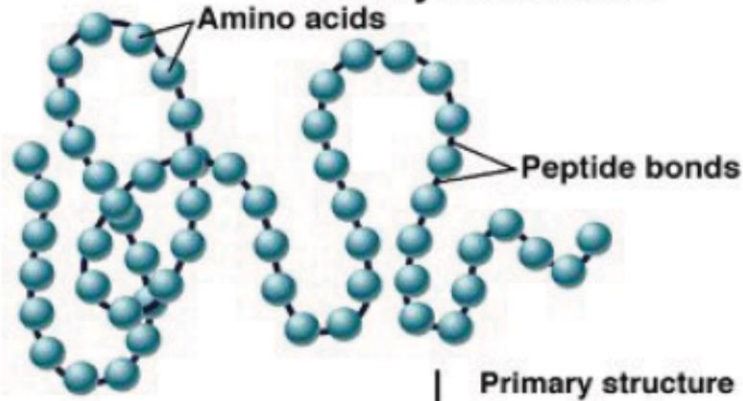
# انواع پیوندها در زنجیره پپتیدی:



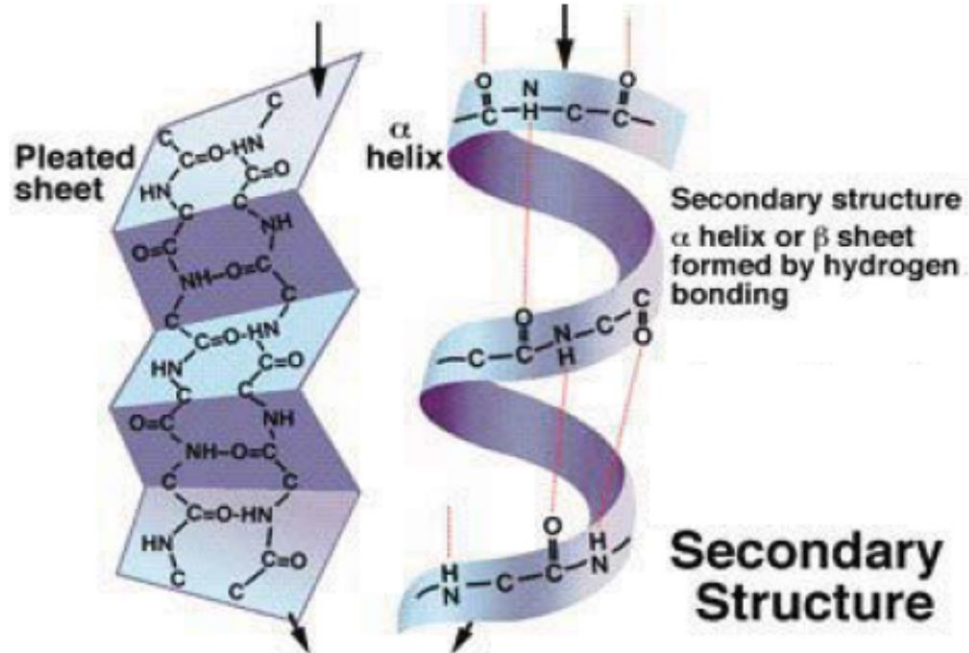


# سطوح ساختاری پروتئین:

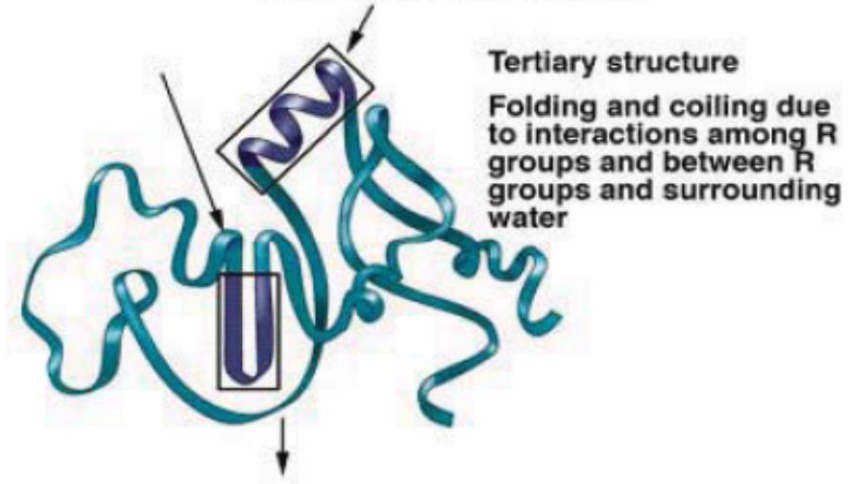
## Levels of Protein Structure — Primary Structure



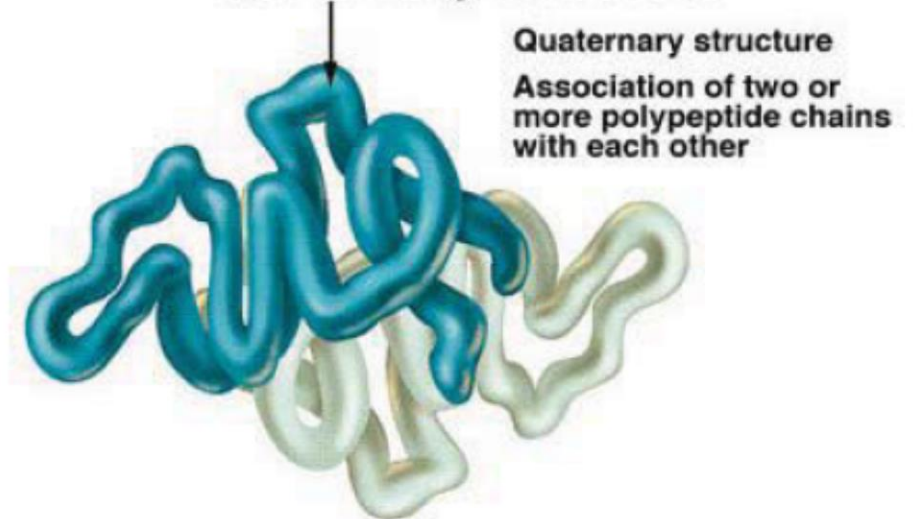
Primary structure  
Sequence of amino acids  
joined by peptide bonds



## Tertiary Structure



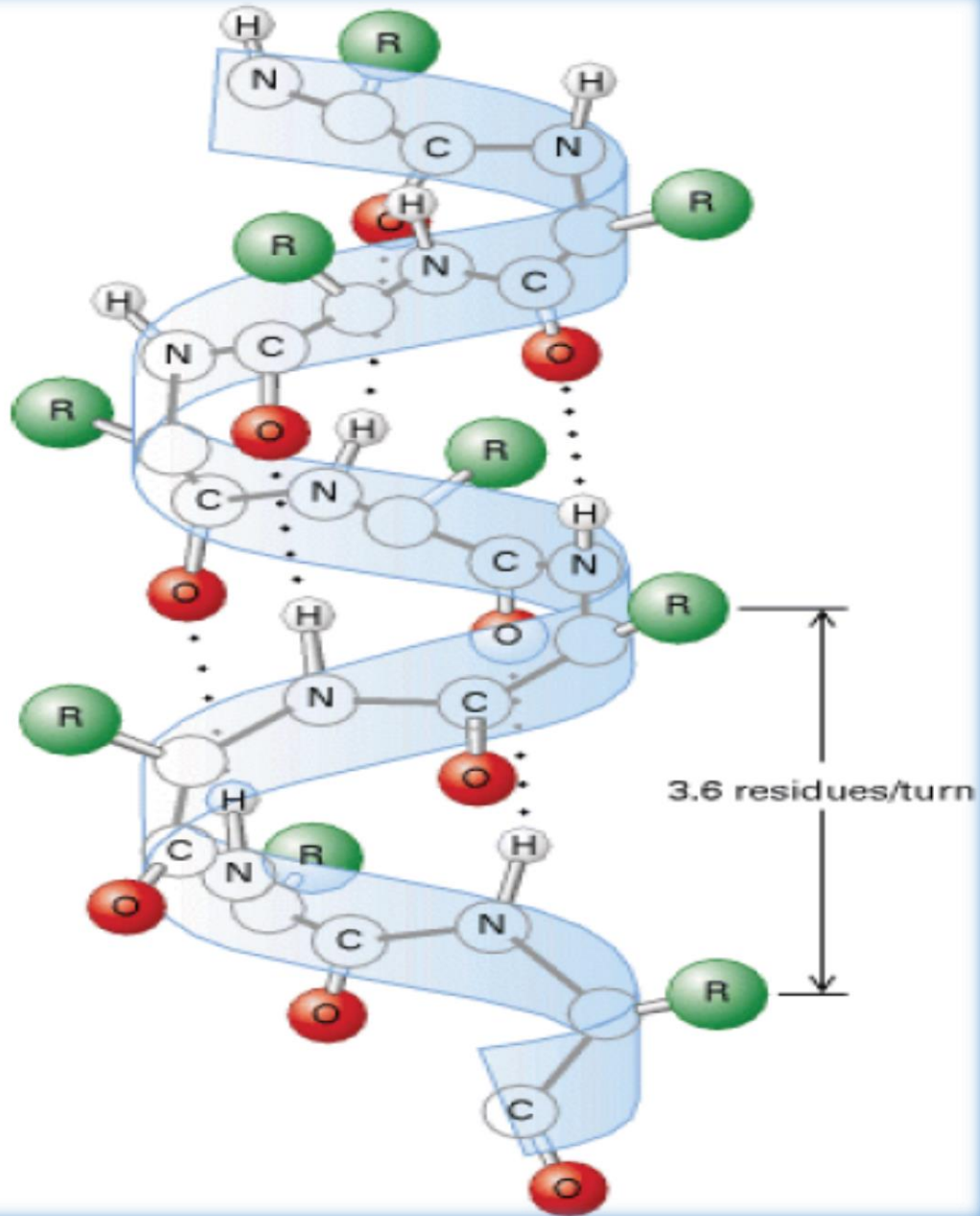
## Quaternary Structure



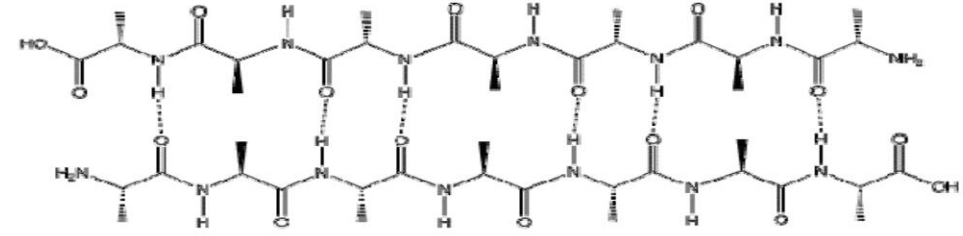
## ساختار اول پروتئین ها:

*N-terminal* NH<sub>2</sub>-Ala-Leu-Val-Thr-Cys .....Arg-His-Phe-Ser-COOH *C-terminal*

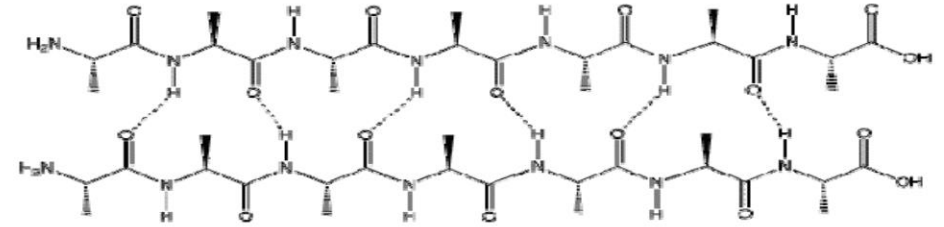
# ساختار دوم پروتئین ها:



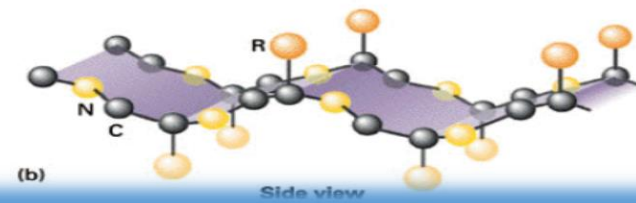
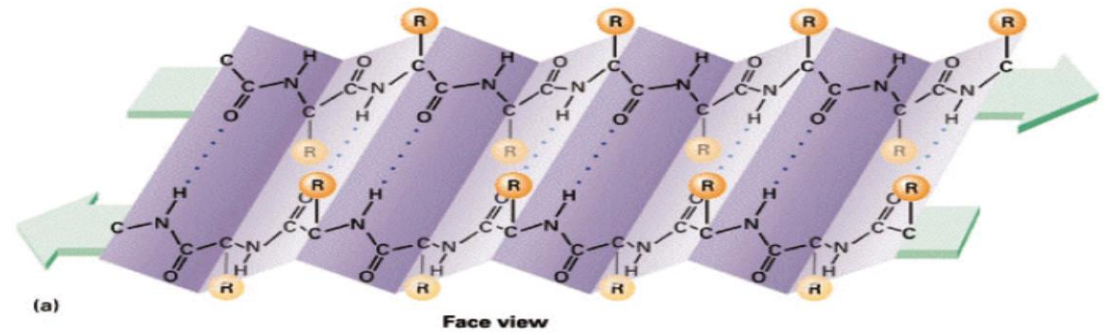
Anti-parallel



Parallel

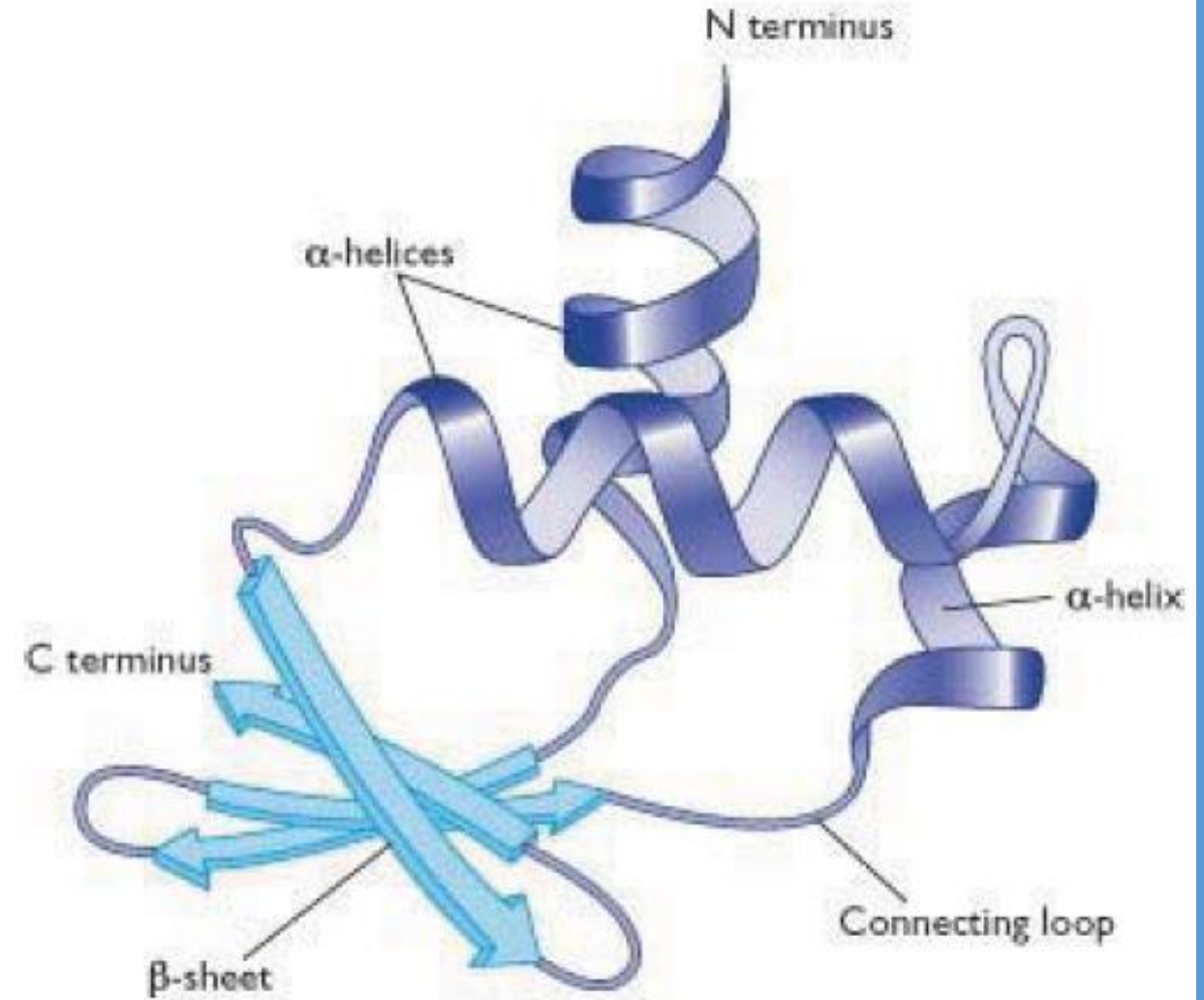
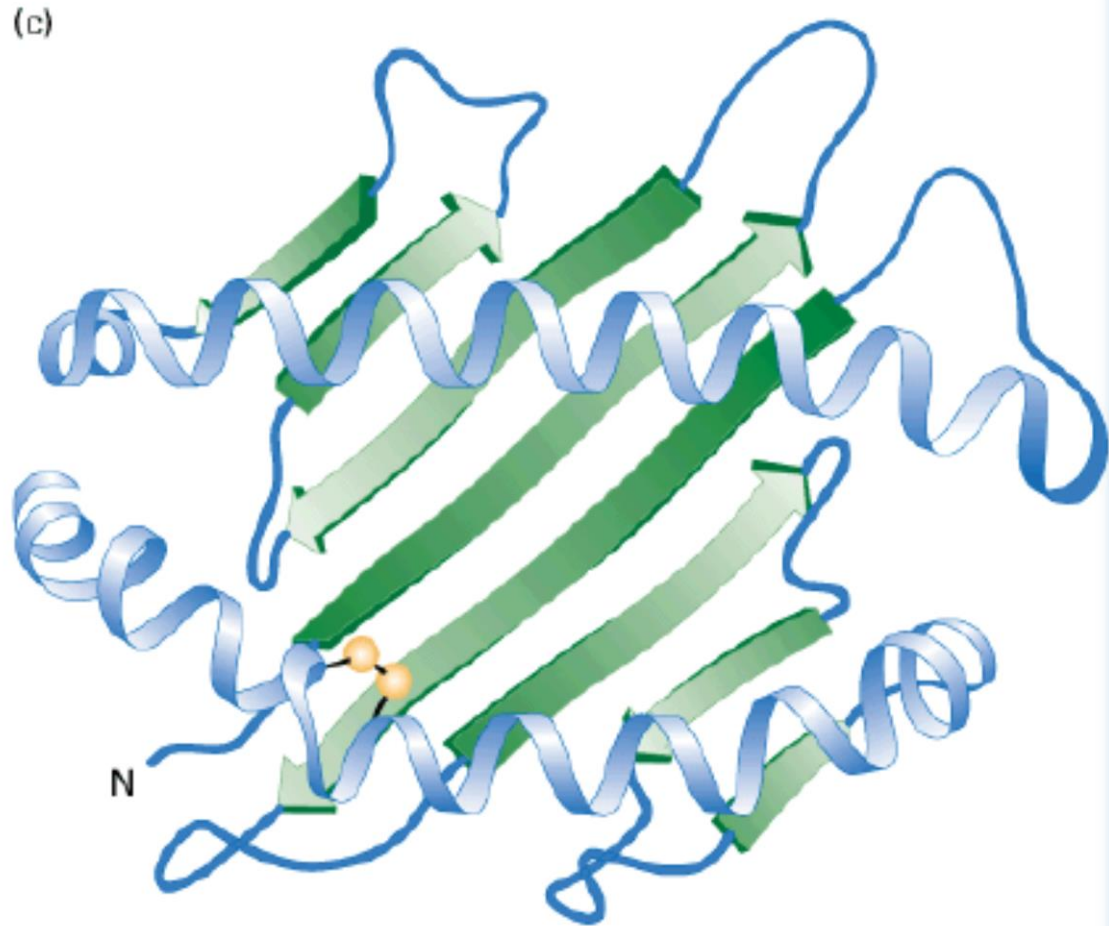


صفحات  $\beta$  موازی همسو و ناهمسو

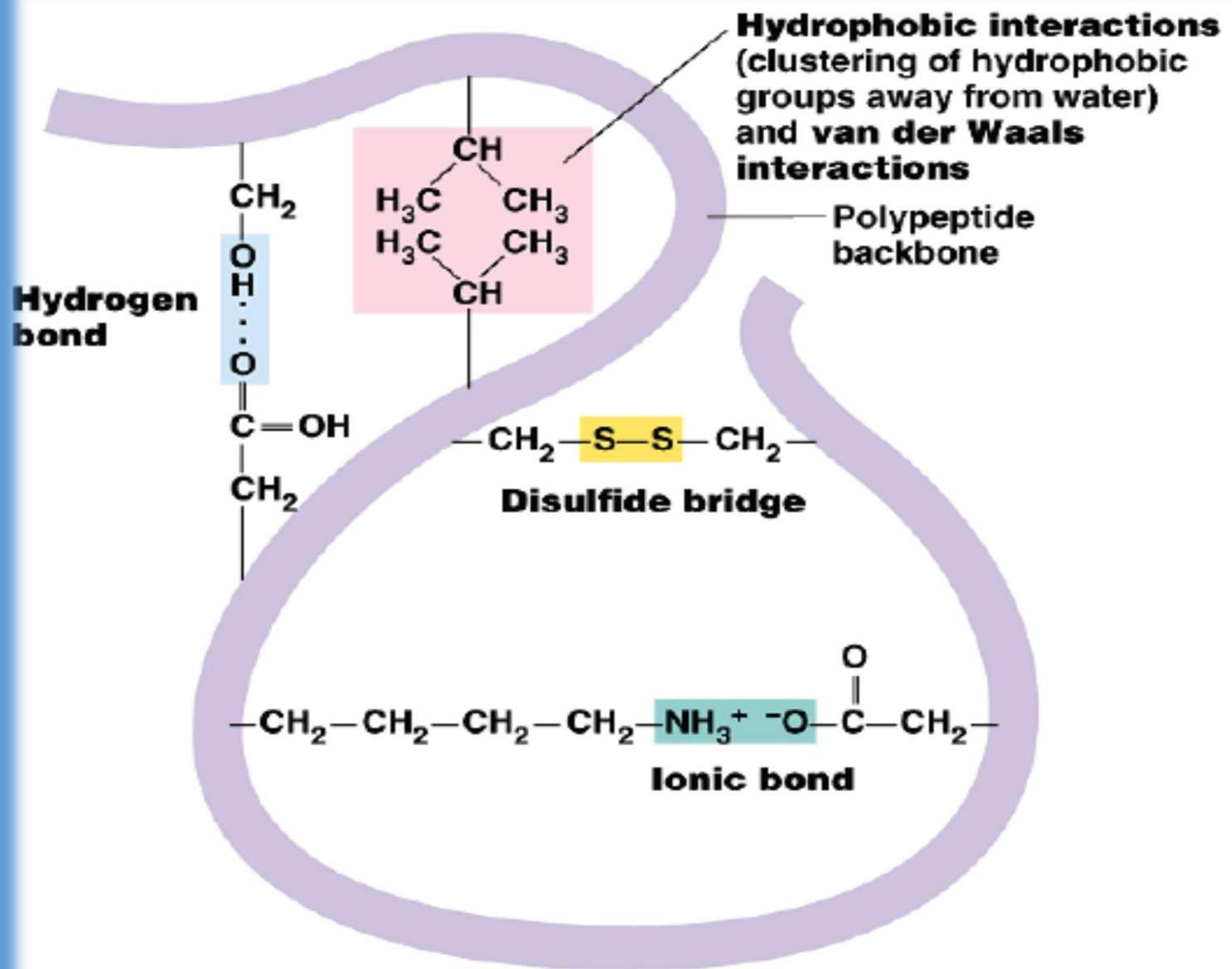




# ساختار سوم پروتئین ها:

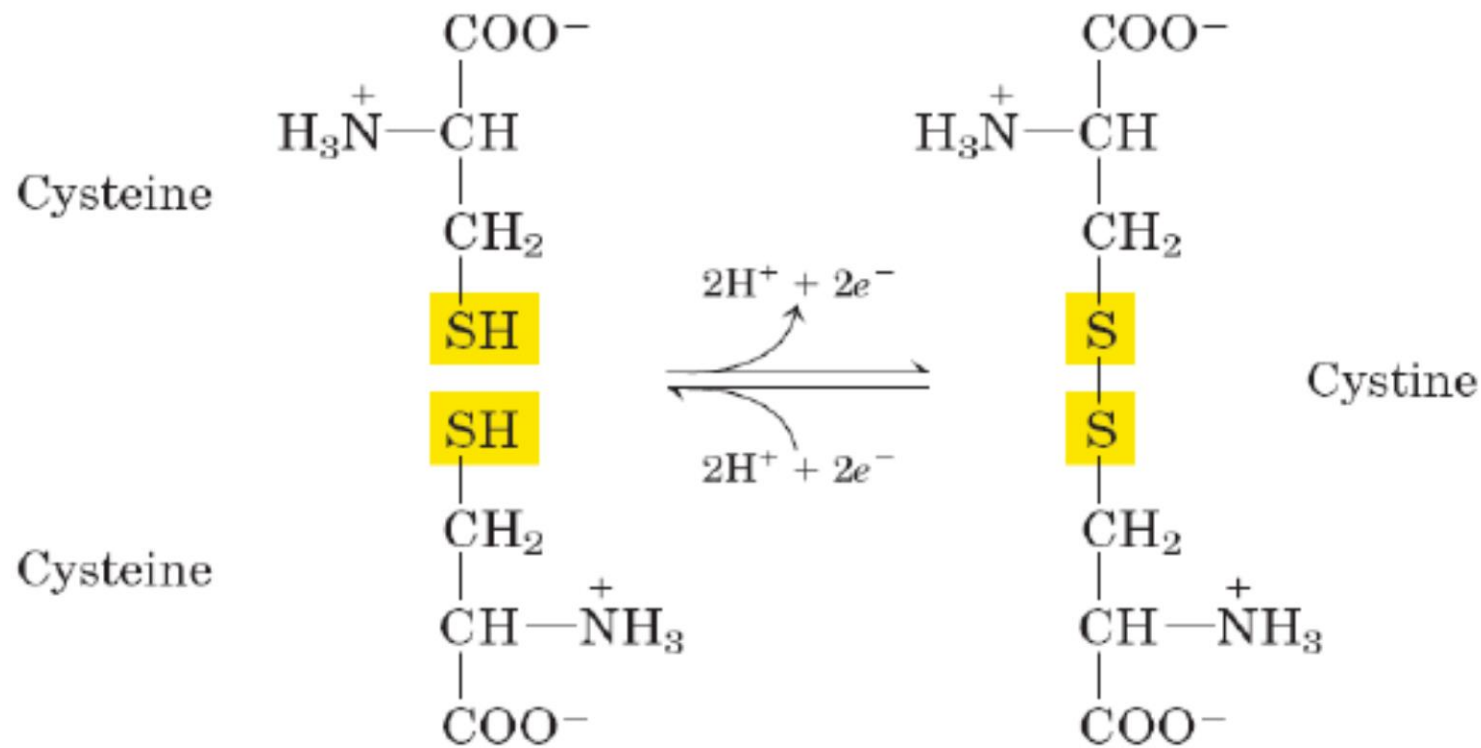


# انواع پیوندها در ساختار سوم پروتئین ها:



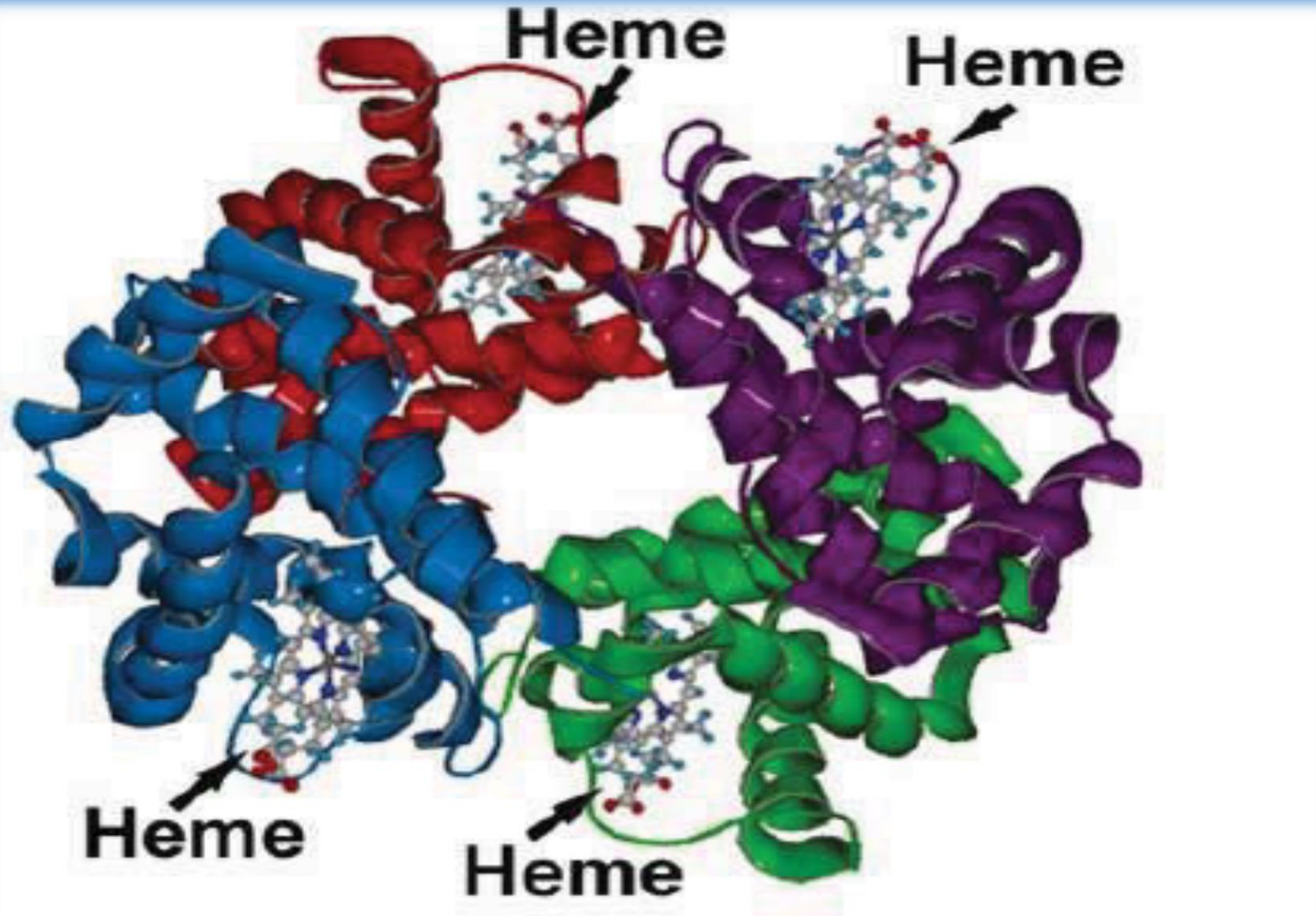


# پیوند دی سولفیدی در ساختار سوم پروتئین ها:

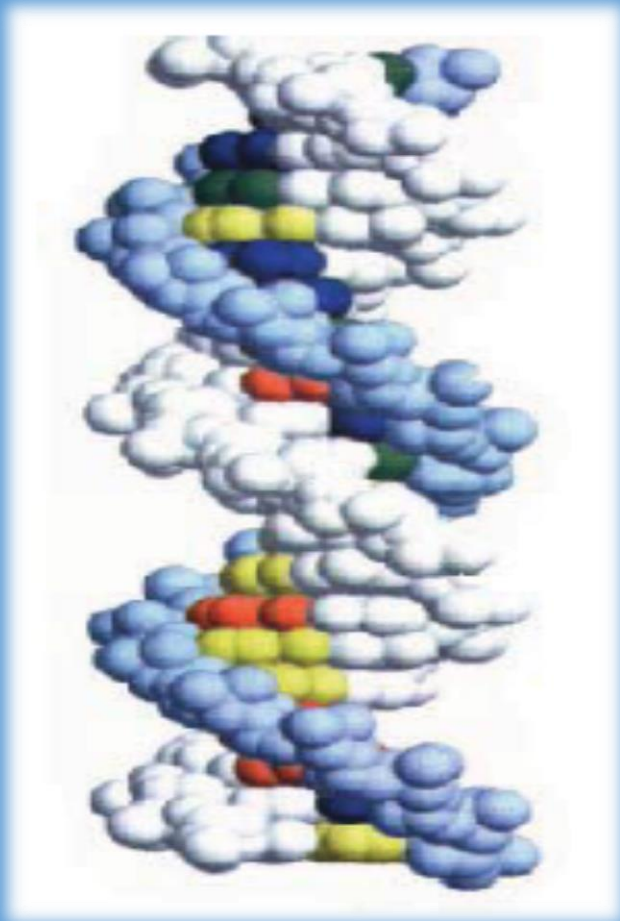


**FIGURE 3-7** Reversible formation of a disulfide bond by the oxidation of two molecules of cysteine. Disulfide bonds between Cys residues stabilize the structures of many proteins.

# ساختار چهارم پروتئین ها:



ساختار چهارم هموگلوبین

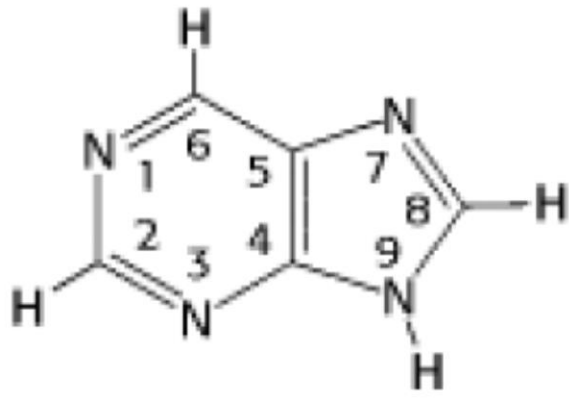


# اسیدهای نوکلئیک ✓

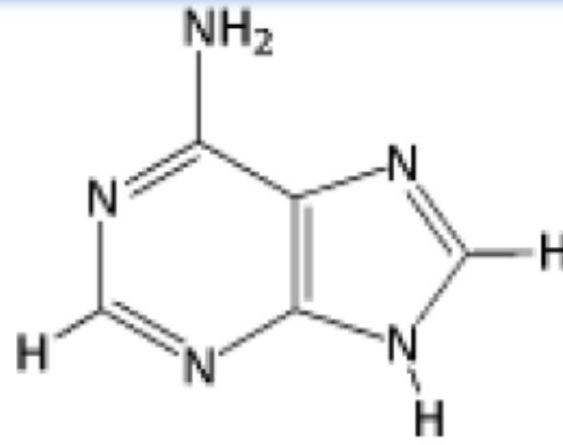
- اهمیت
- ویژگی ها
- ساختمان شیمیایی

# بازهای آلی نیتروژن دار در ساختار اسیدهای نوکلئیک:

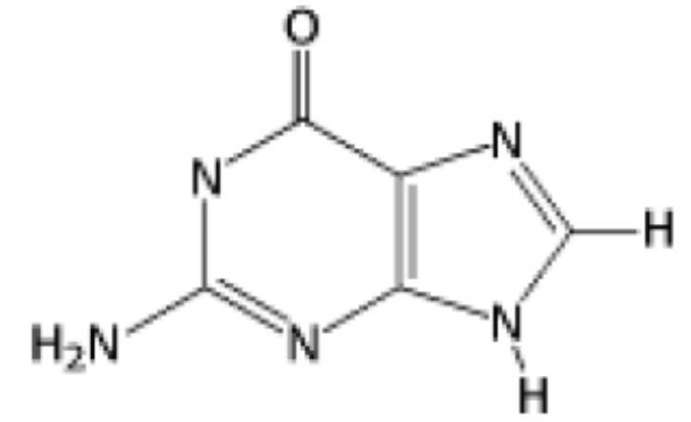
PURINES



Purine

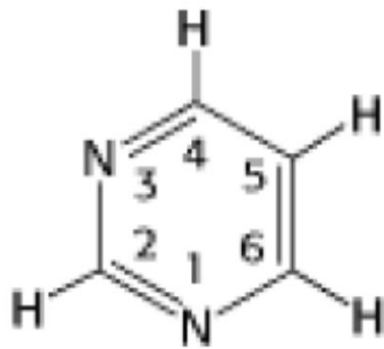


Adenine

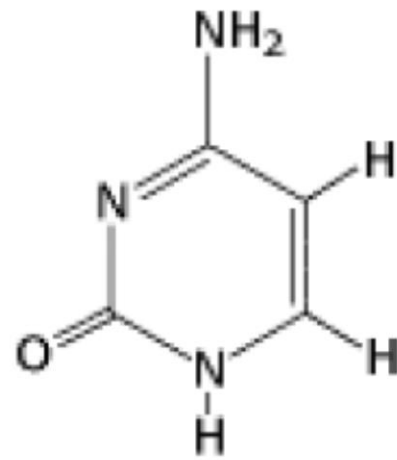


Guanine

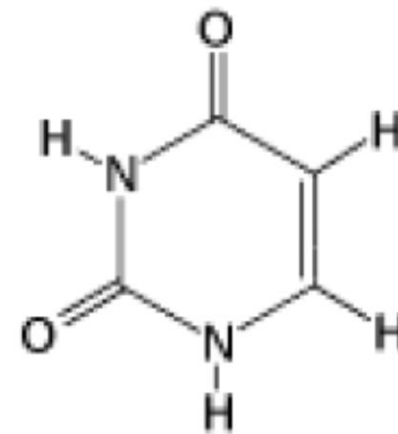
PYRIMIDINES



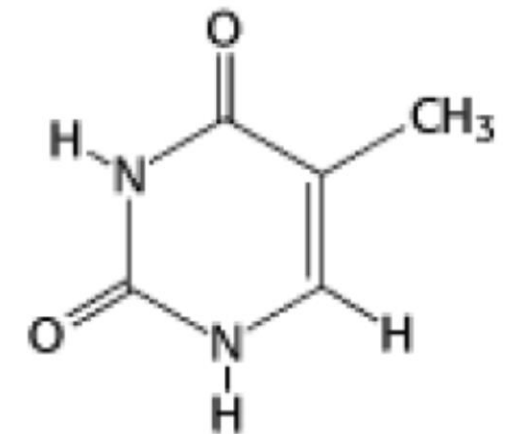
Pyrimidine



Cytosine

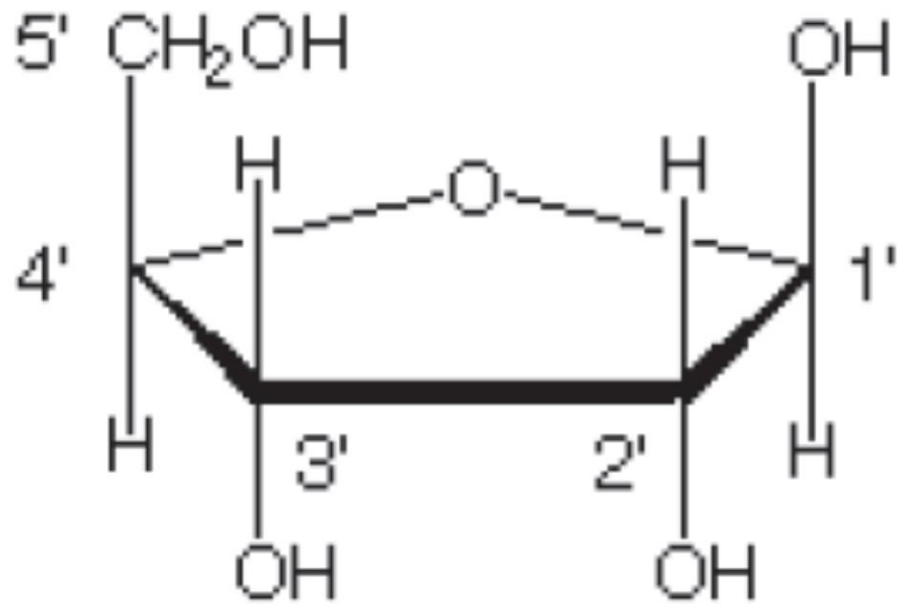


Uracil

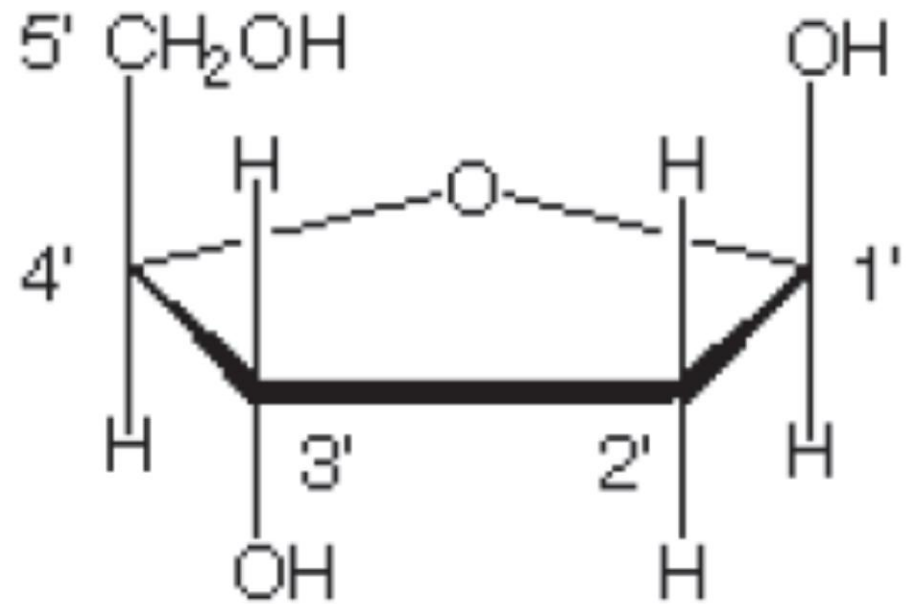


Thymine

## قندها در ساختار اسیدهای نوکلئیک:



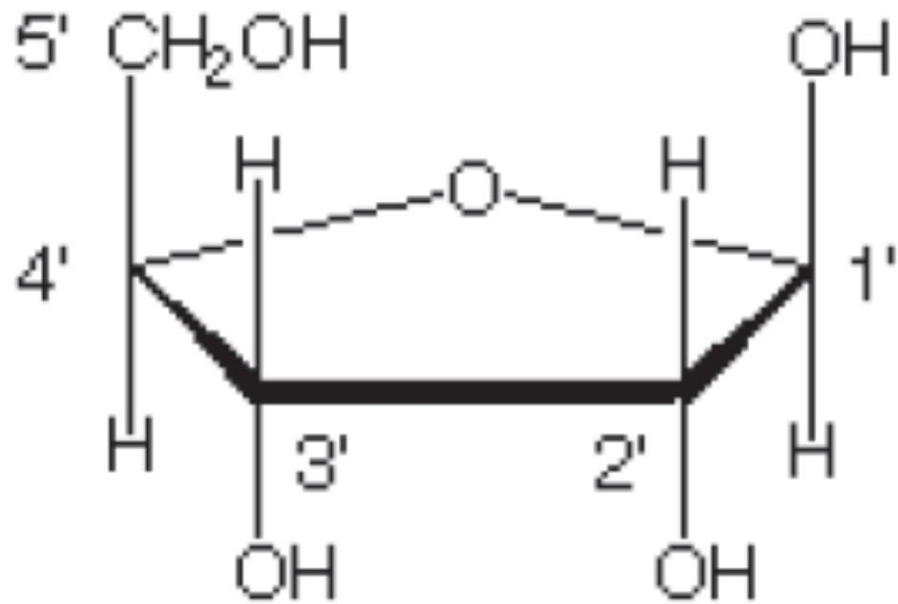
**Ribose**



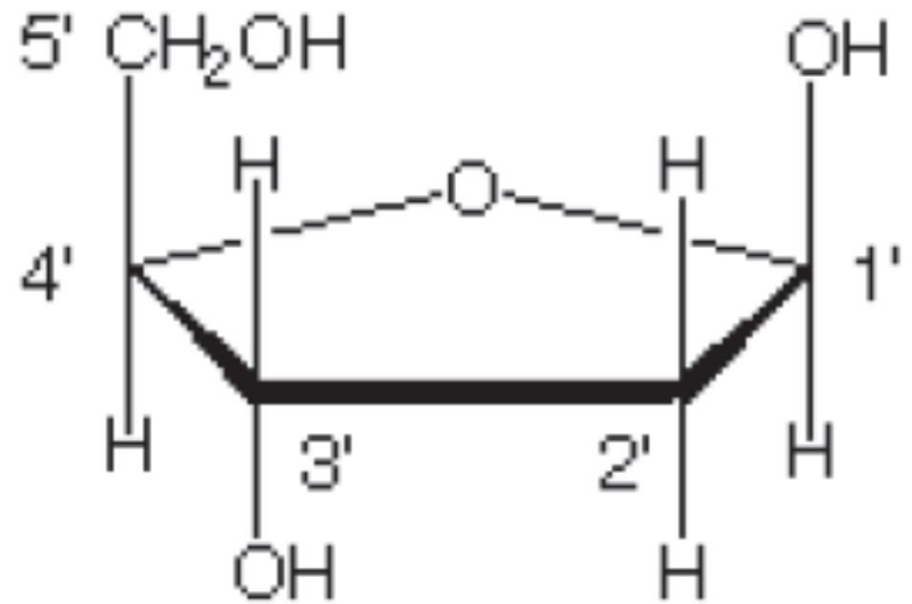
**Deoxyribose**



# قندها در ساختار اسیدهای نوکلئیک:

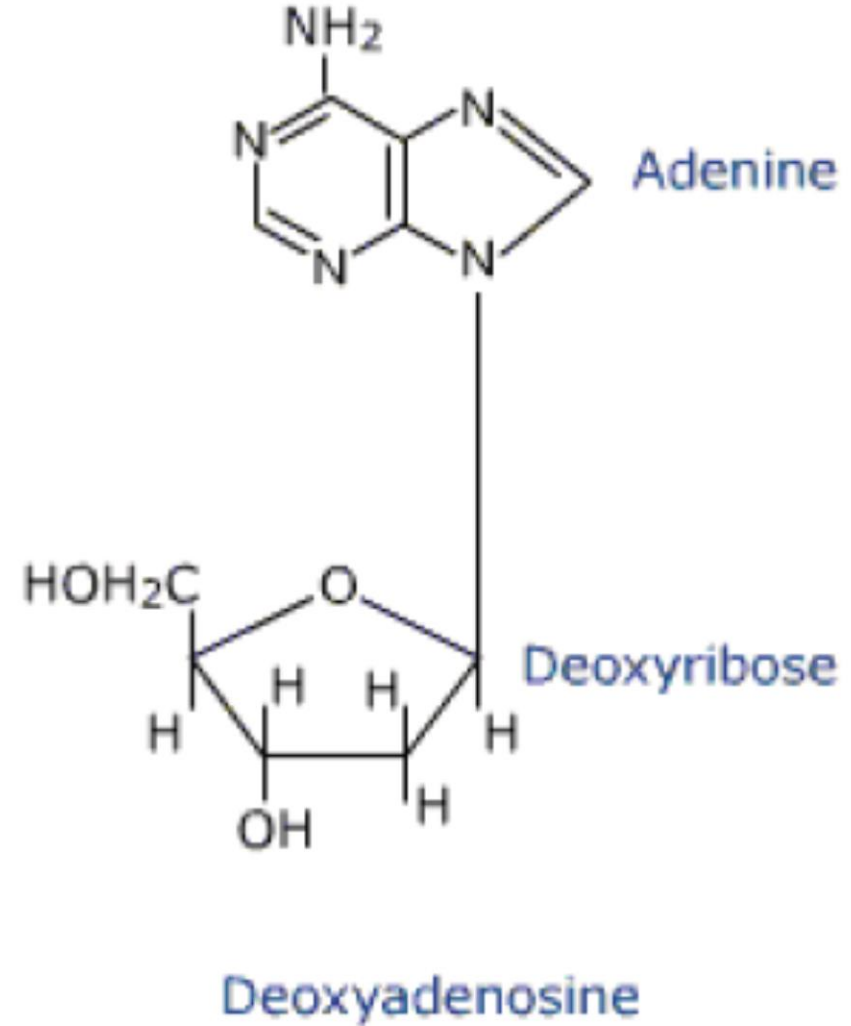
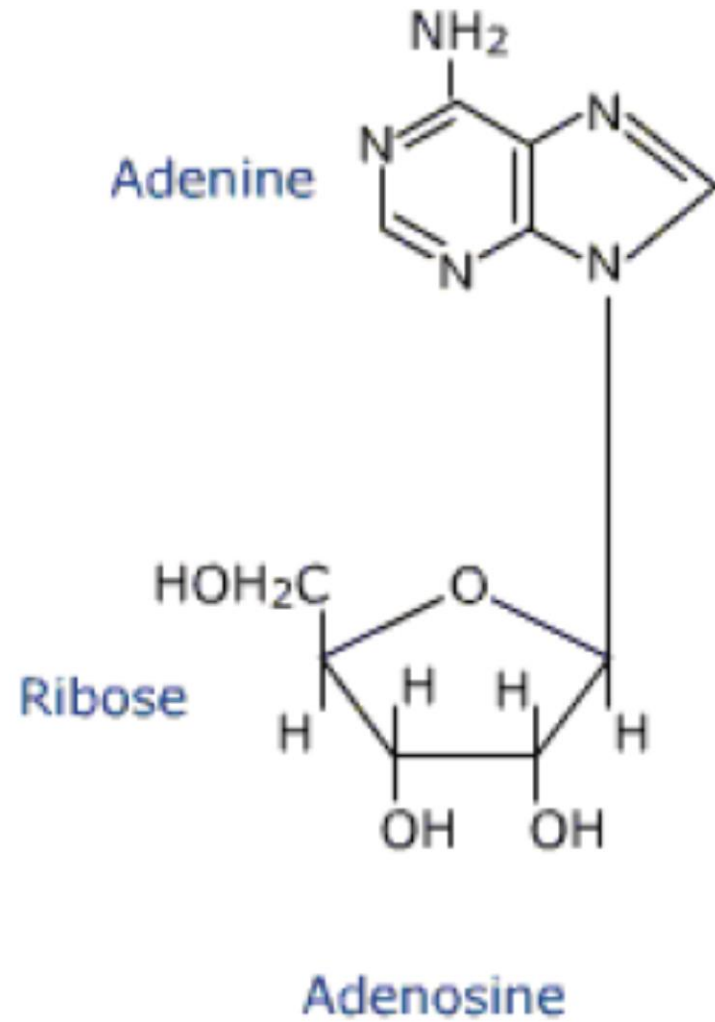


**Ribose**

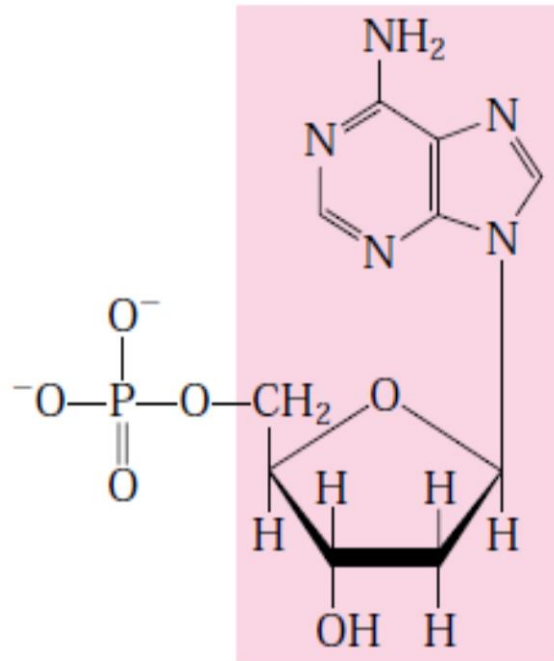


**Deoxyribose**

# ساختمان نوکلئوزید:



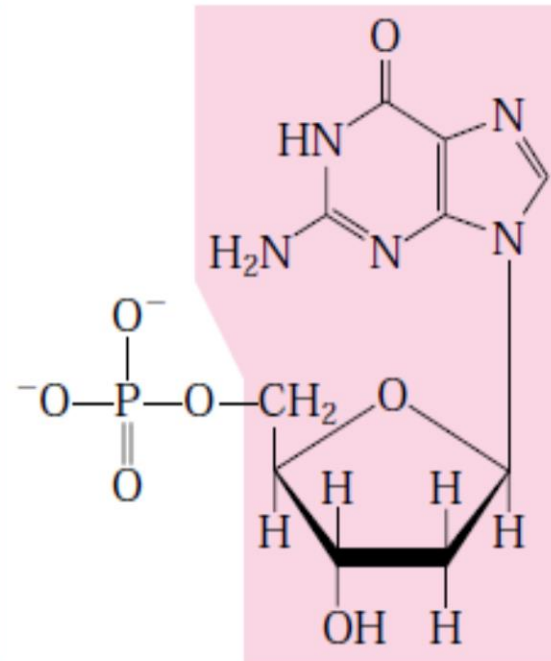
# ساختمان نوکلئوتید:



**Nucleotide:** Deoxyadenylate  
(deoxyadenosine  
5'-monophosphate)

**Symbols:** A, dA, dAMP

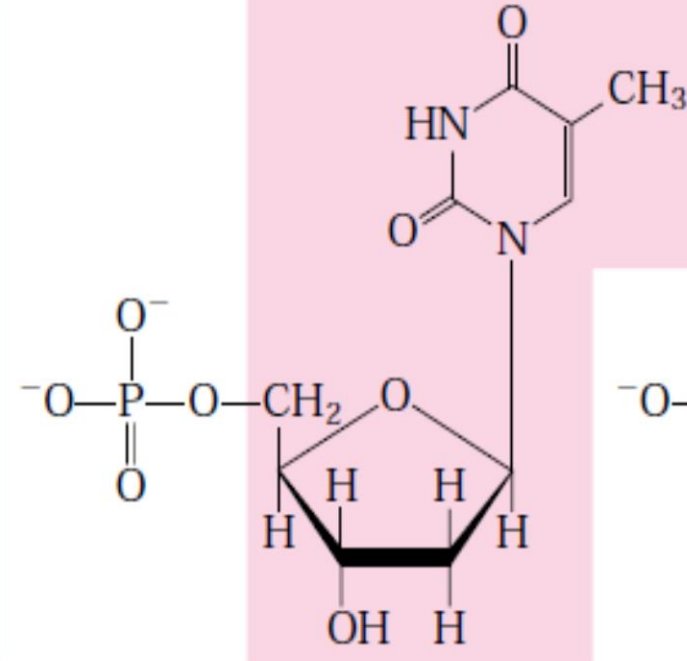
**Nucleoside:** Deoxyadenosine



**Nucleotide:** Deoxyguanylate  
(deoxyguanosine  
5'-monophosphate)

**Symbols:** G, dG, dGMP

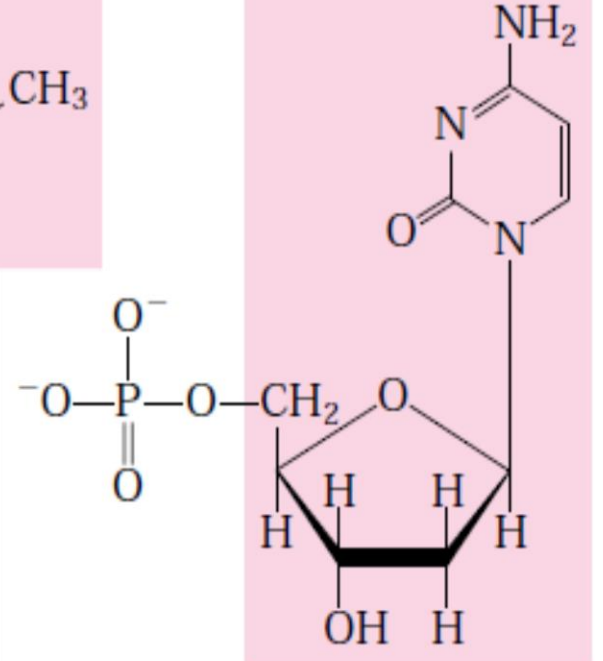
**Nucleoside:** Deoxyguanosine



**Nucleotide:** Deoxythymidylate  
(deoxythymidine  
5'-monophosphate)

**Symbols:** T, dT, dTMP

**Nucleoside:** Deoxythymidine



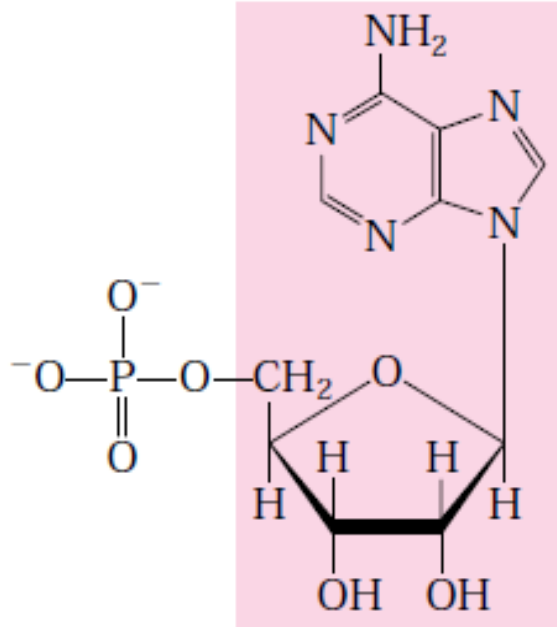
**Nucleotide:** Deoxycytidylate  
(deoxycytidine  
5'-monophosphate)

**Symbols:** C, dC, dCMP

**Nucleoside:** Deoxycytidine

(a) Deoxyribonucleotides

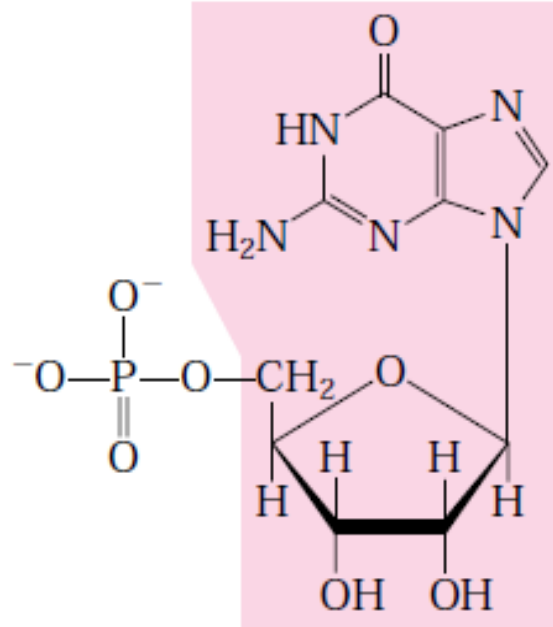
# ساختمان نوکلئوتید:



**Nucleotide:** Adenylate (adenosine 5'-monophosphate)

**Symbols:** A, AMP

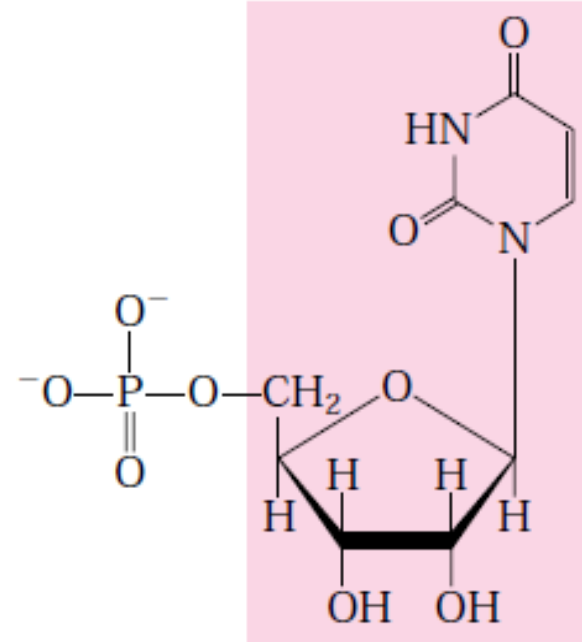
**Nucleoside:** Adenosine



**Nucleotide:** Guanylate (guanosine 5'-monophosphate)

**Symbols:** G, GMP

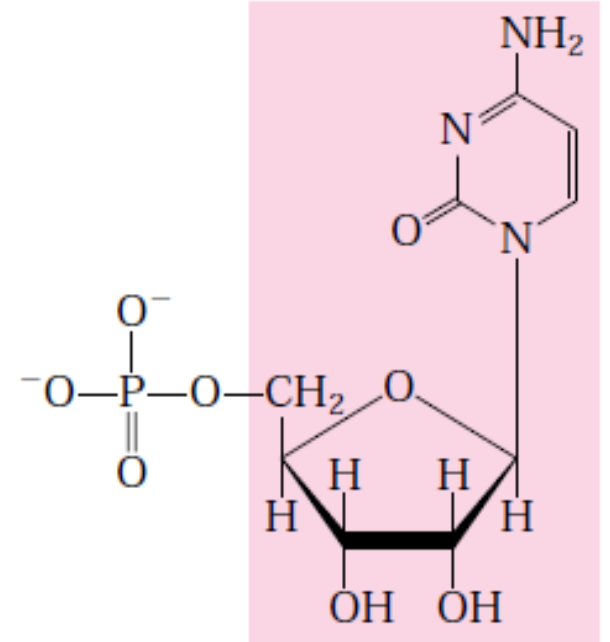
**Nucleoside:** Guanosine



**Nucleotide:** Uridylate (uridine 5'-monophosphate)

**Symbols:** U, UMP

**Nucleoside:** Uridine



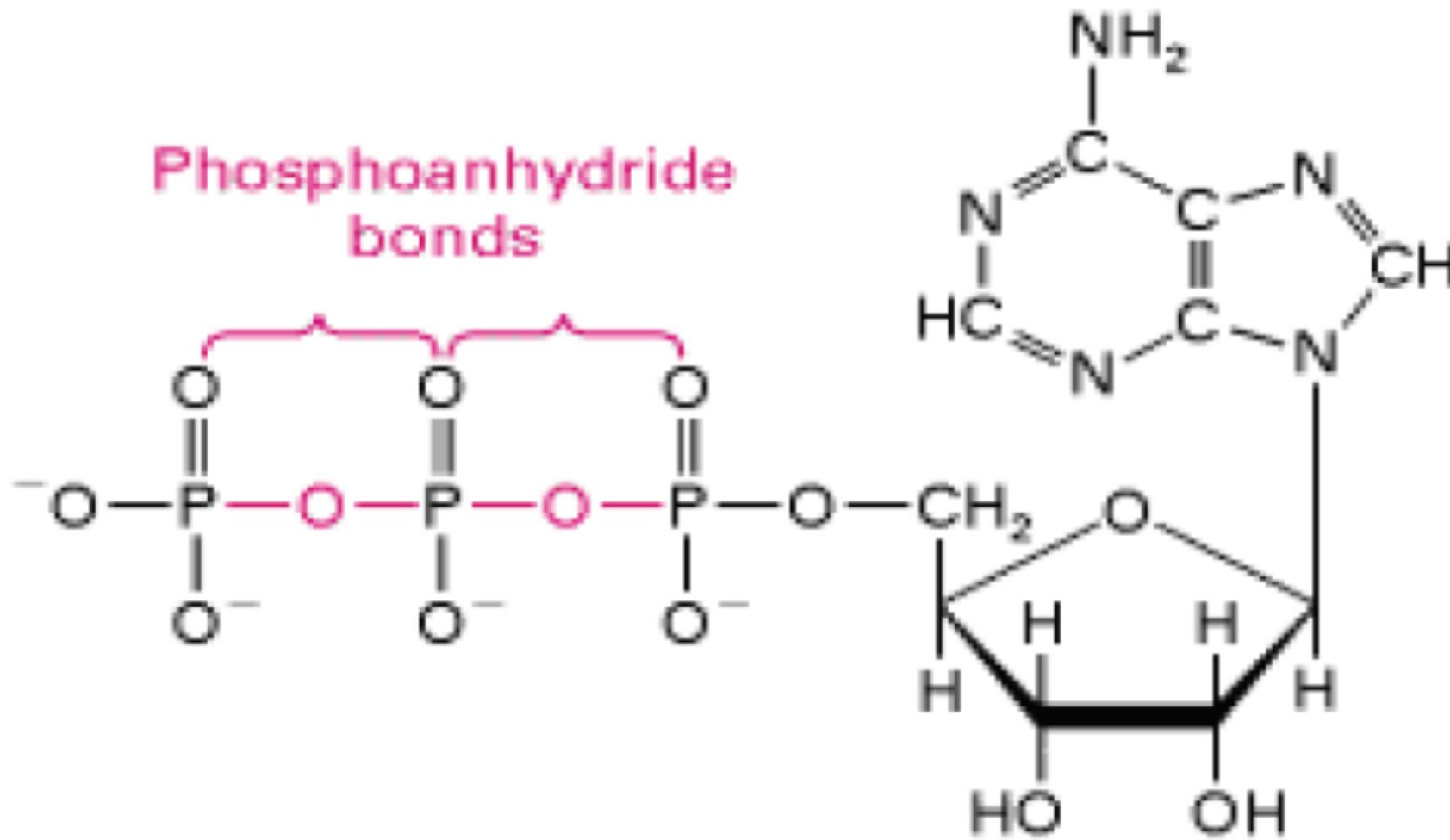
**Nucleotide:** Cytidylate (cytidine 5'-monophosphate)

**Symbols:** C, CMP

**Nucleoside:** Cytidine

(b) Ribonucleotides

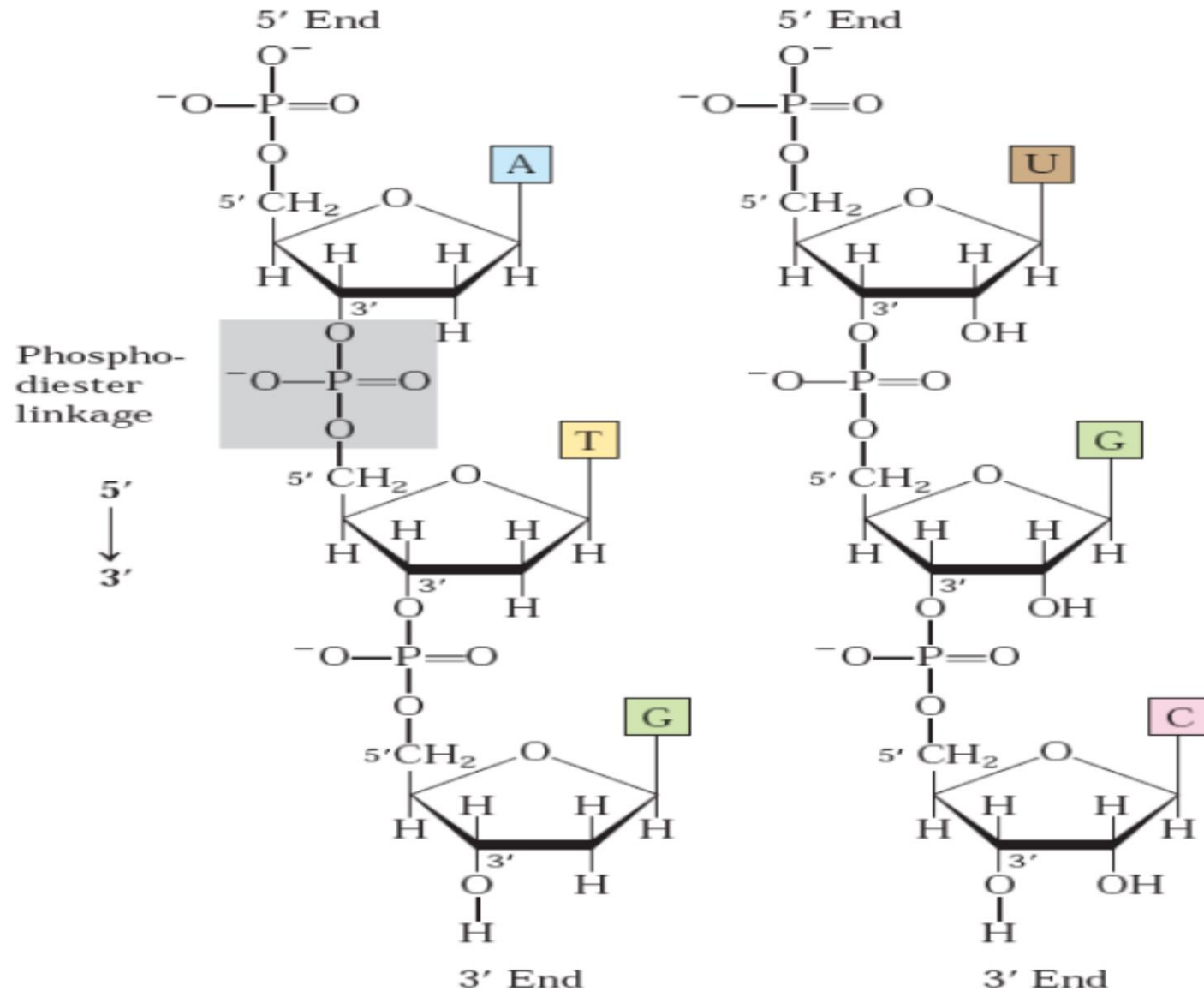
# پیوند فسفوانیدرید:



Adenosine triphosphate  
(ATP)

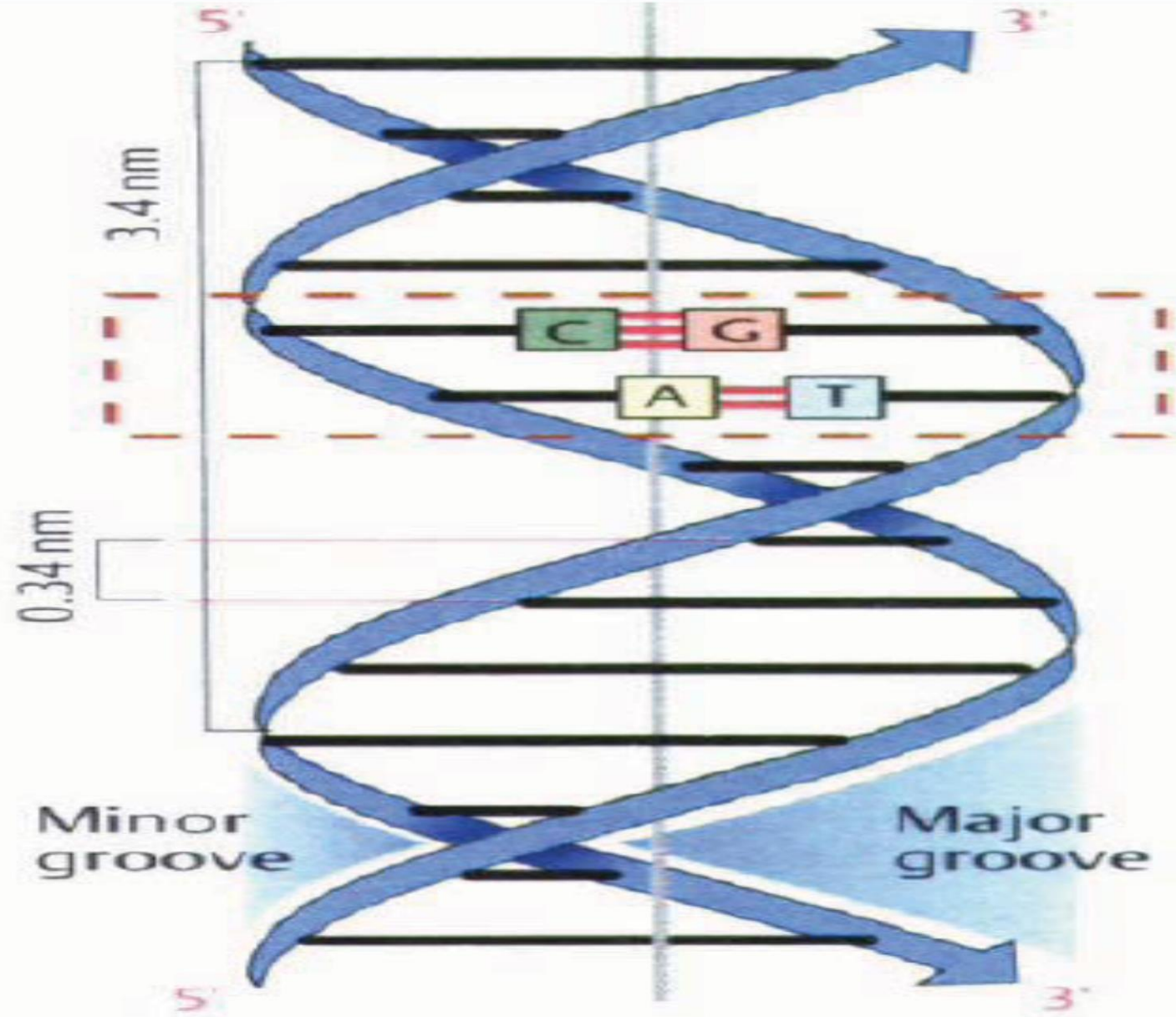


# پیوند فسفودی استری:



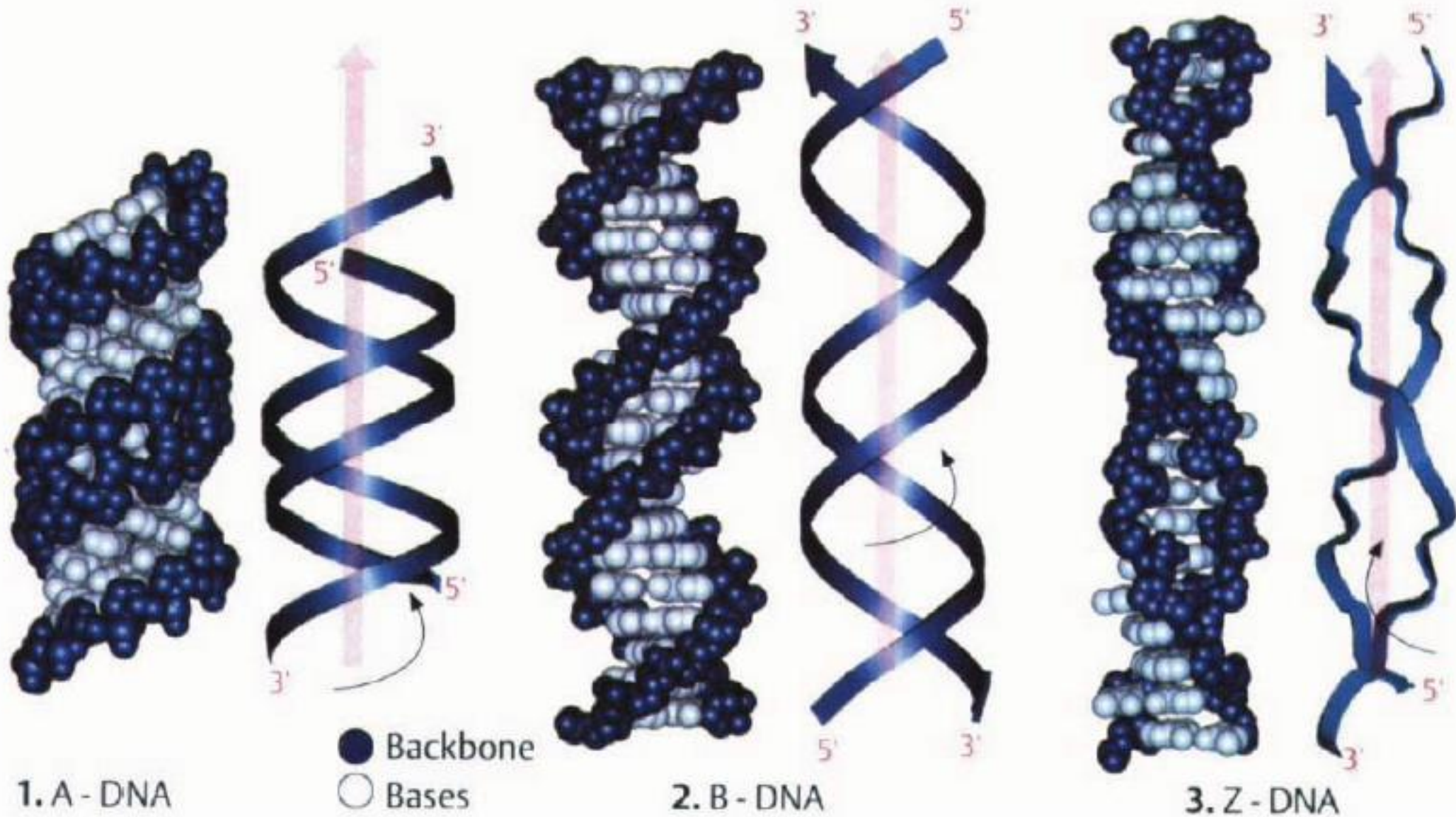
**FIGURE 8-7** Phosphodiester linkages in the covalent backbone of DNA and RNA.

# ساختار دوم DNA:

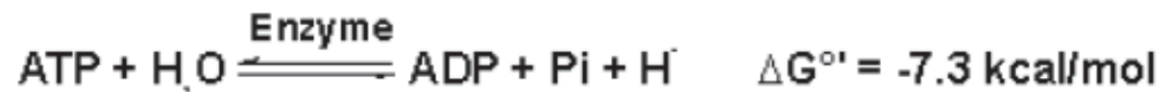
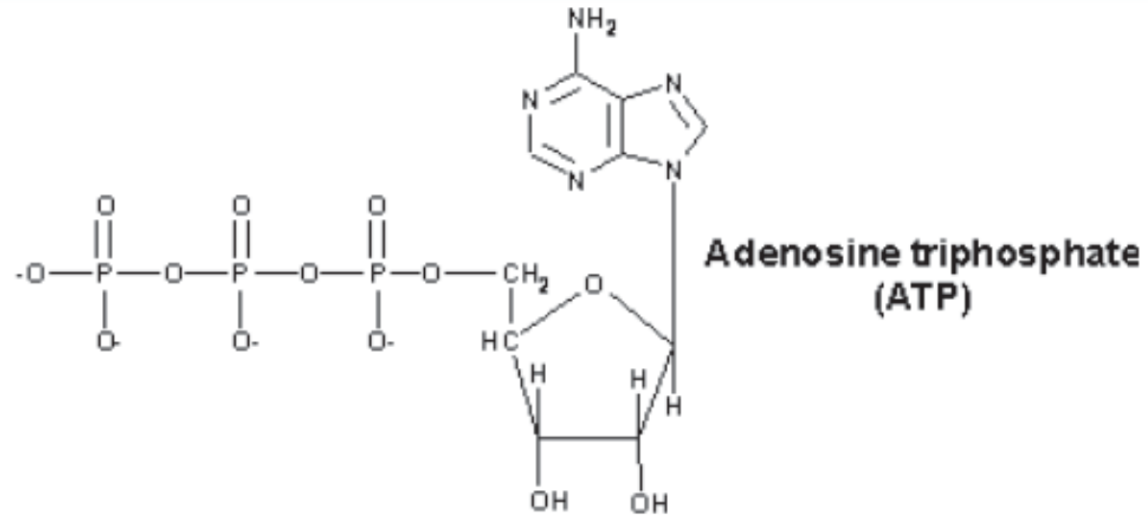


2. Double strand

# ساختار دوم DNA:

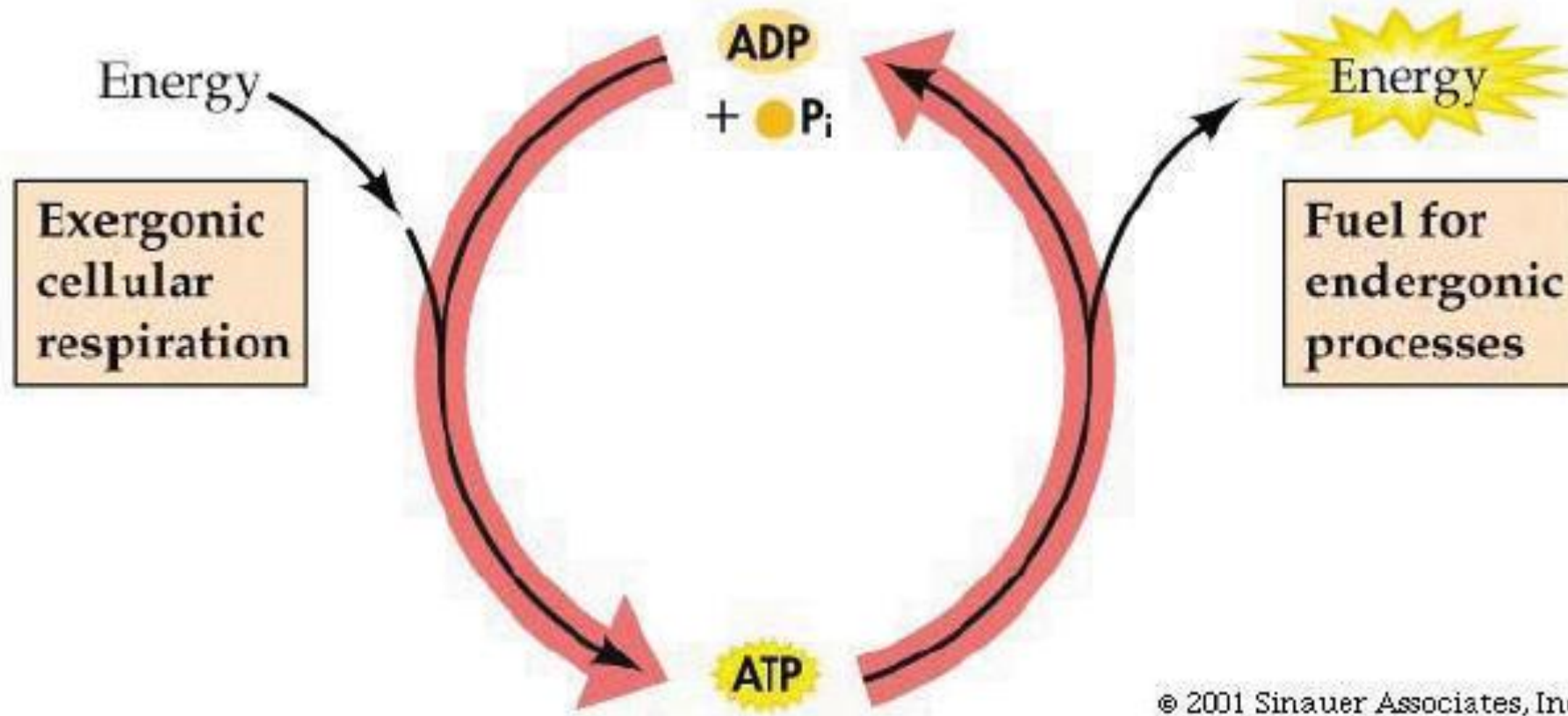


# نوکلئوتیدها به عنوان ناقل انرژی:



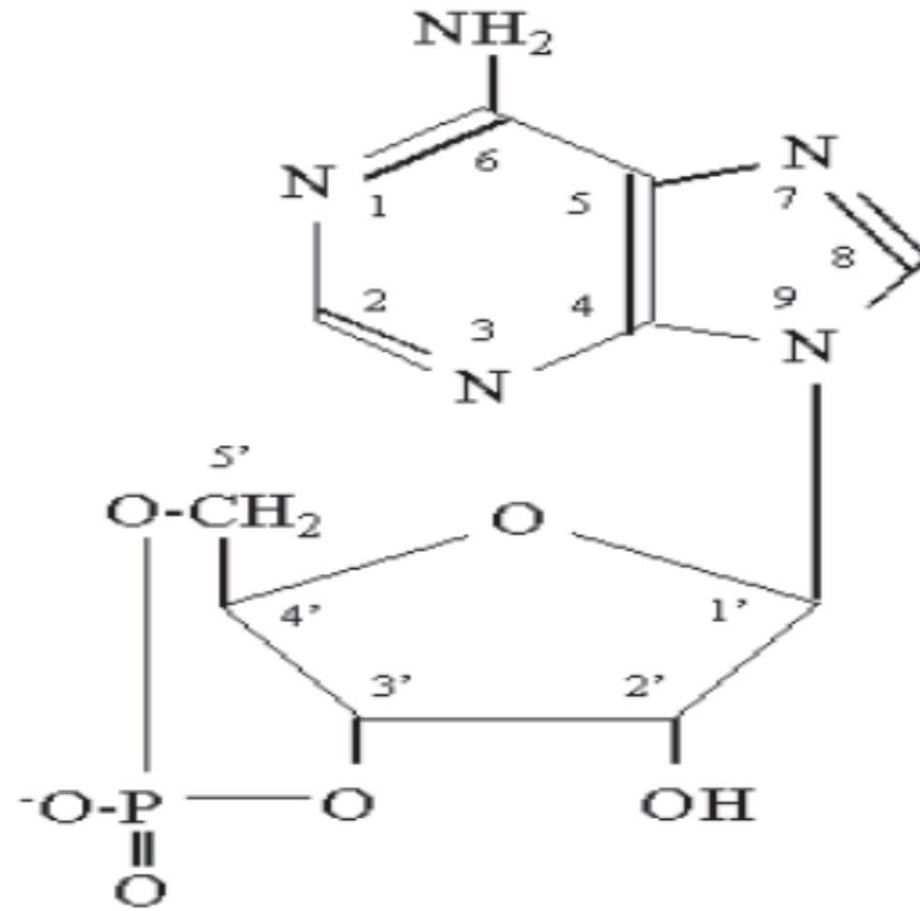


# نوکلئوتیدها به عنوان ناقل انرژی:

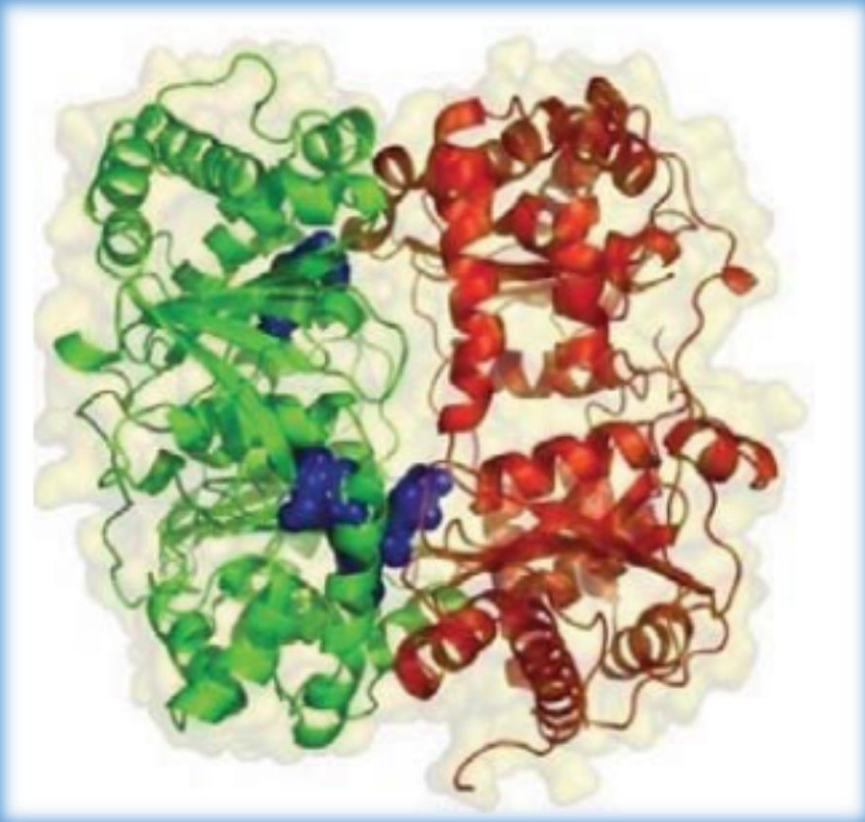




# نوکلئوتیدها به عنوان مولکول های تنظیمی:



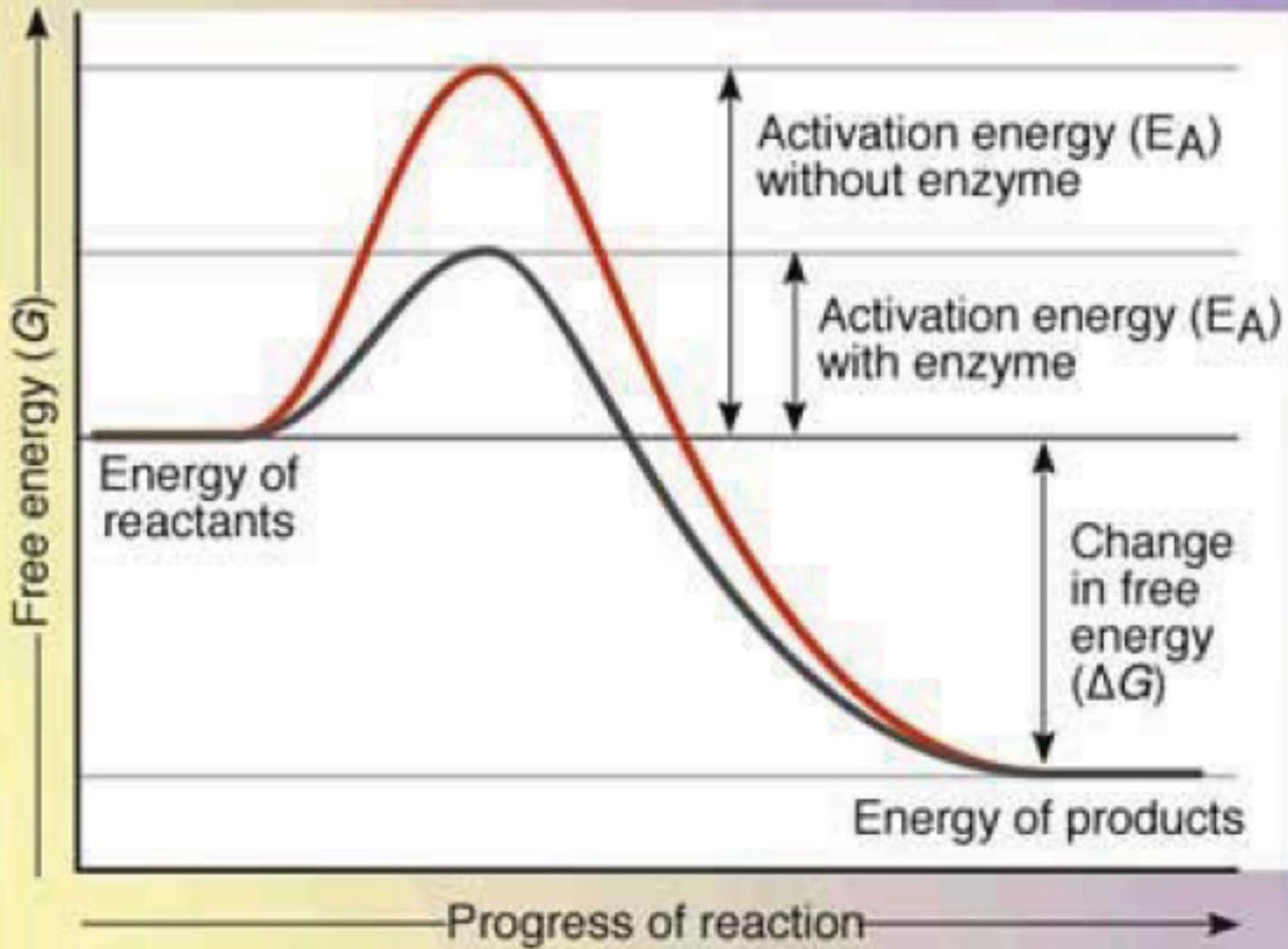
cyclic AMP



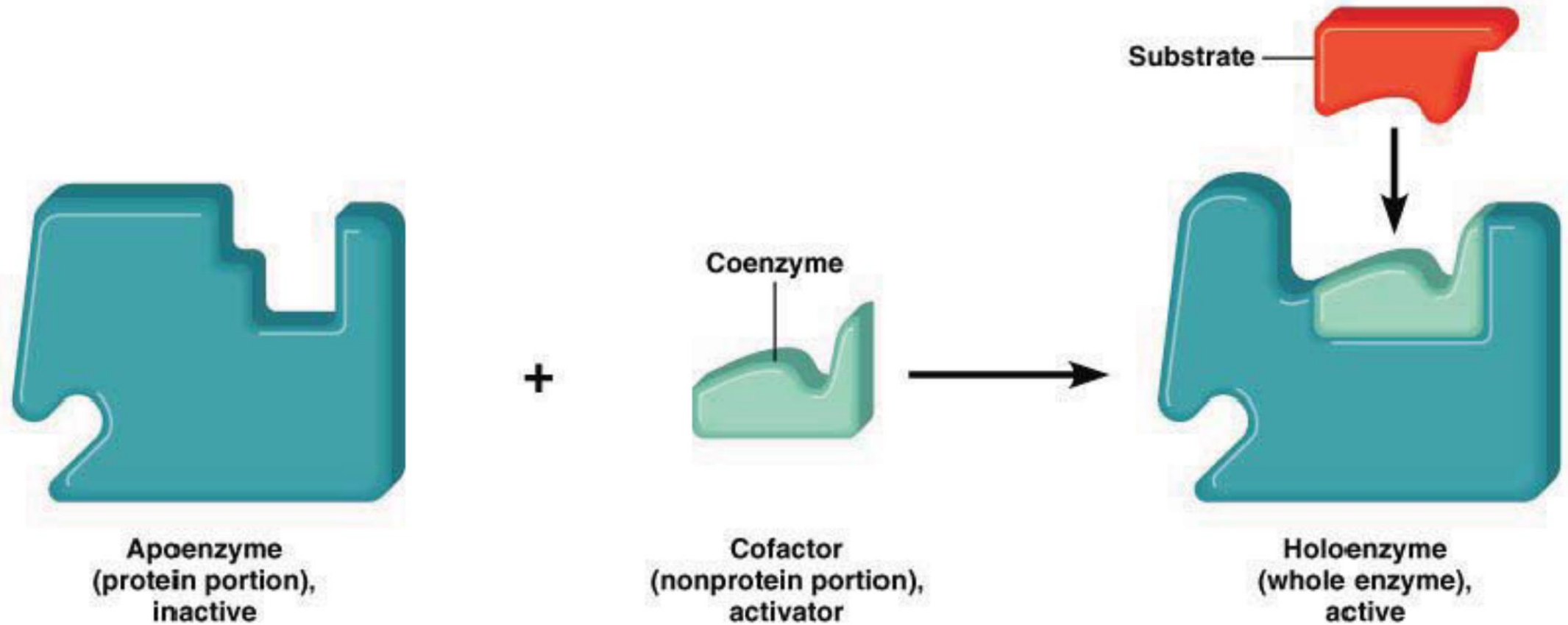
# آنزیم‌ها: ✓

- اهمیت
- ویژگی‌ها
- ساختمان شیمیایی

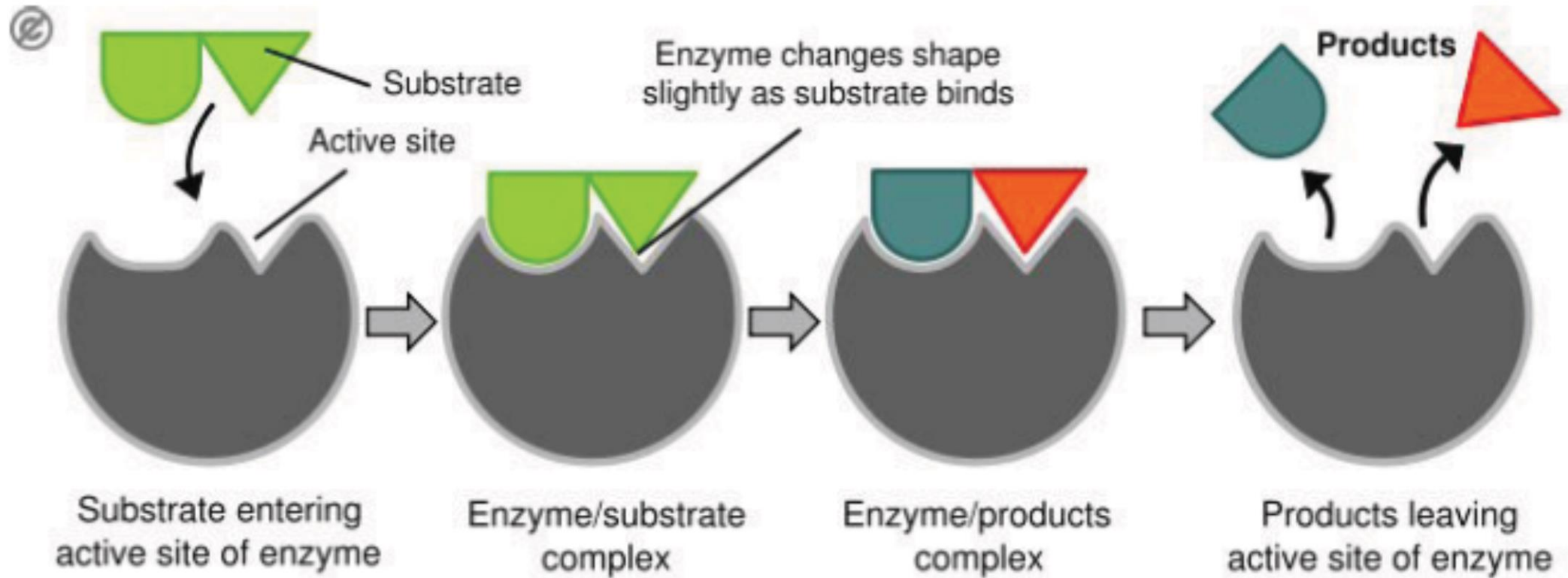
# افزایش سرعت واکنشها توسط آنزیمها:



# ساختار آنزیم‌ها:

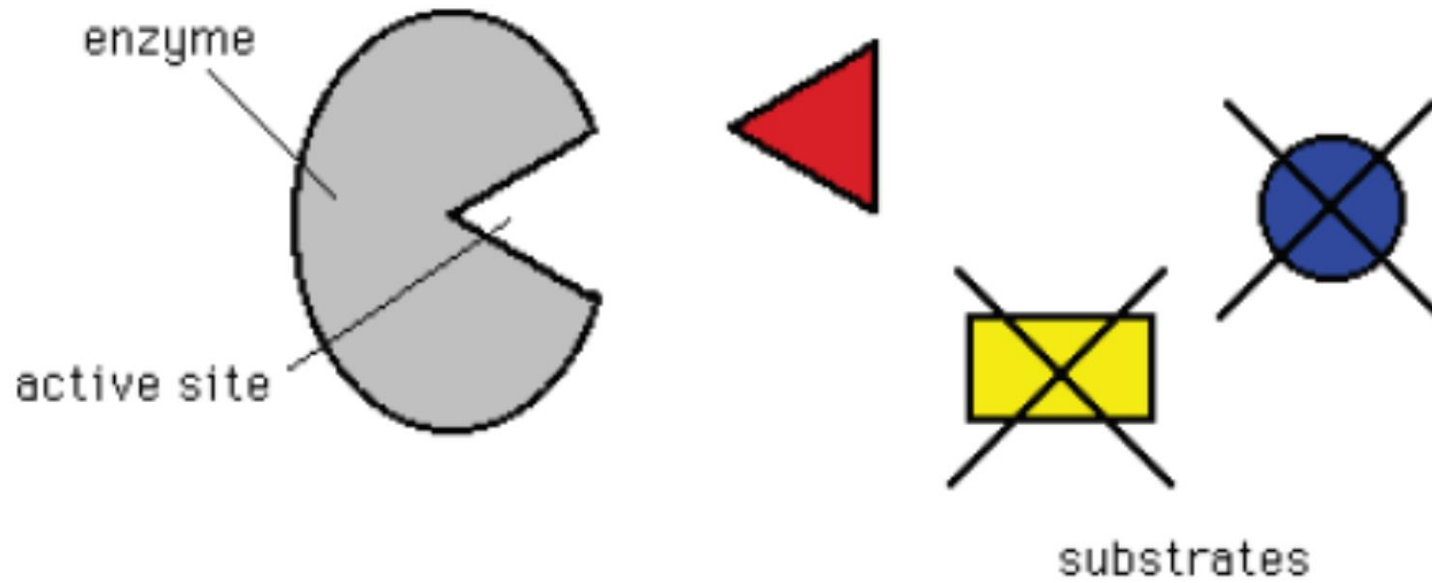


# ساختار آنزیم‌ها:



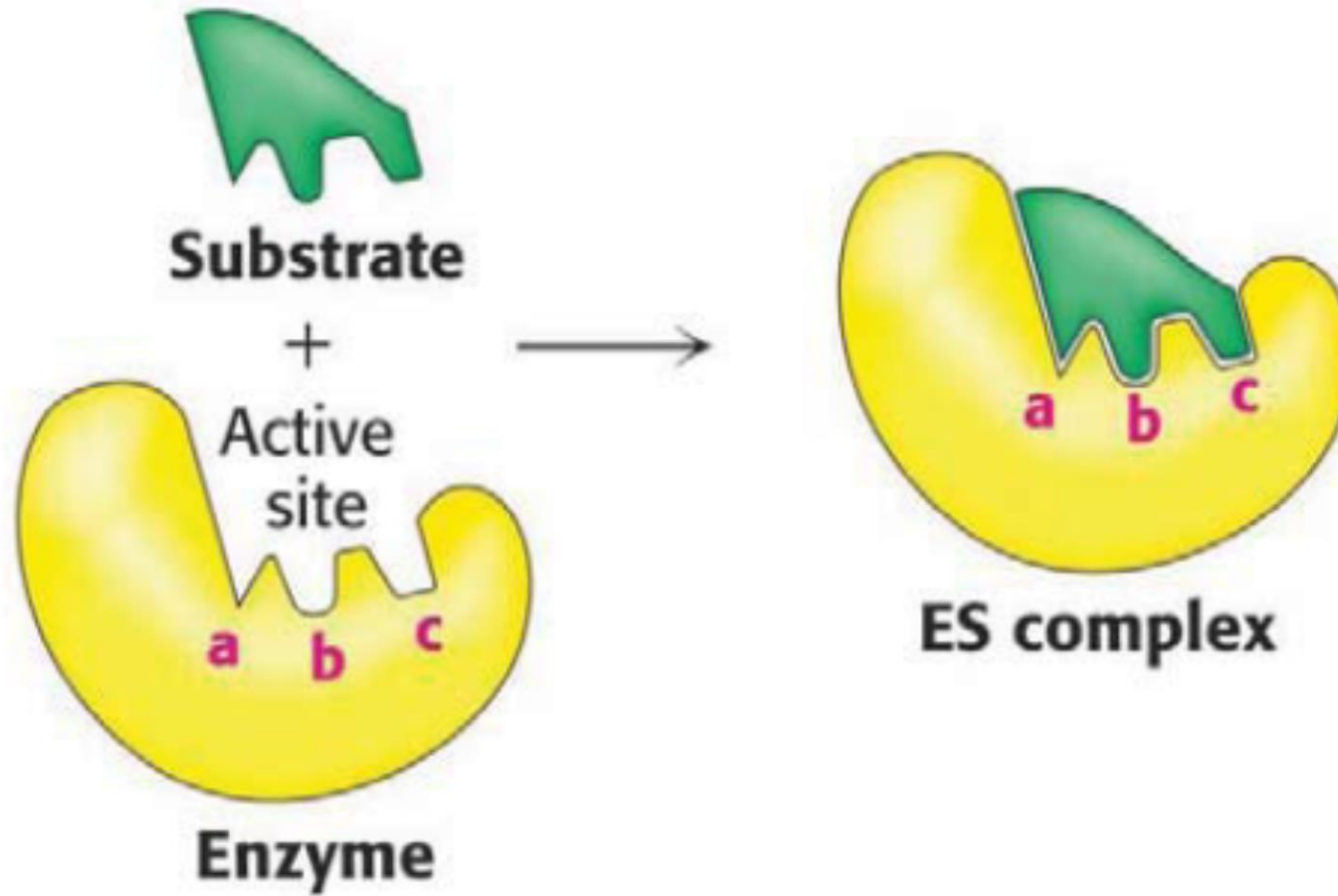


# عمل اختصاصی آنزیم‌ها:

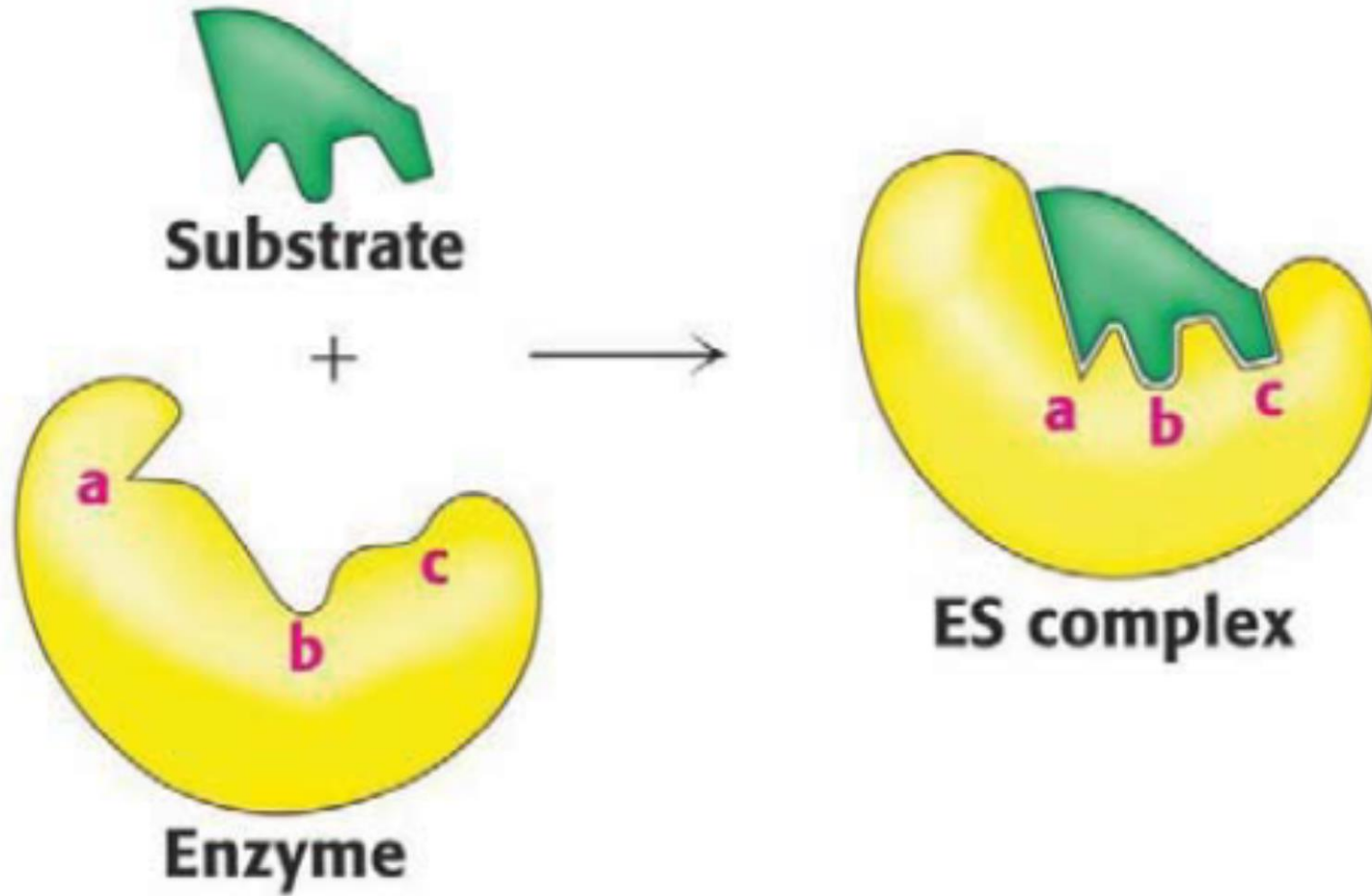


"Complementarity of Fit"

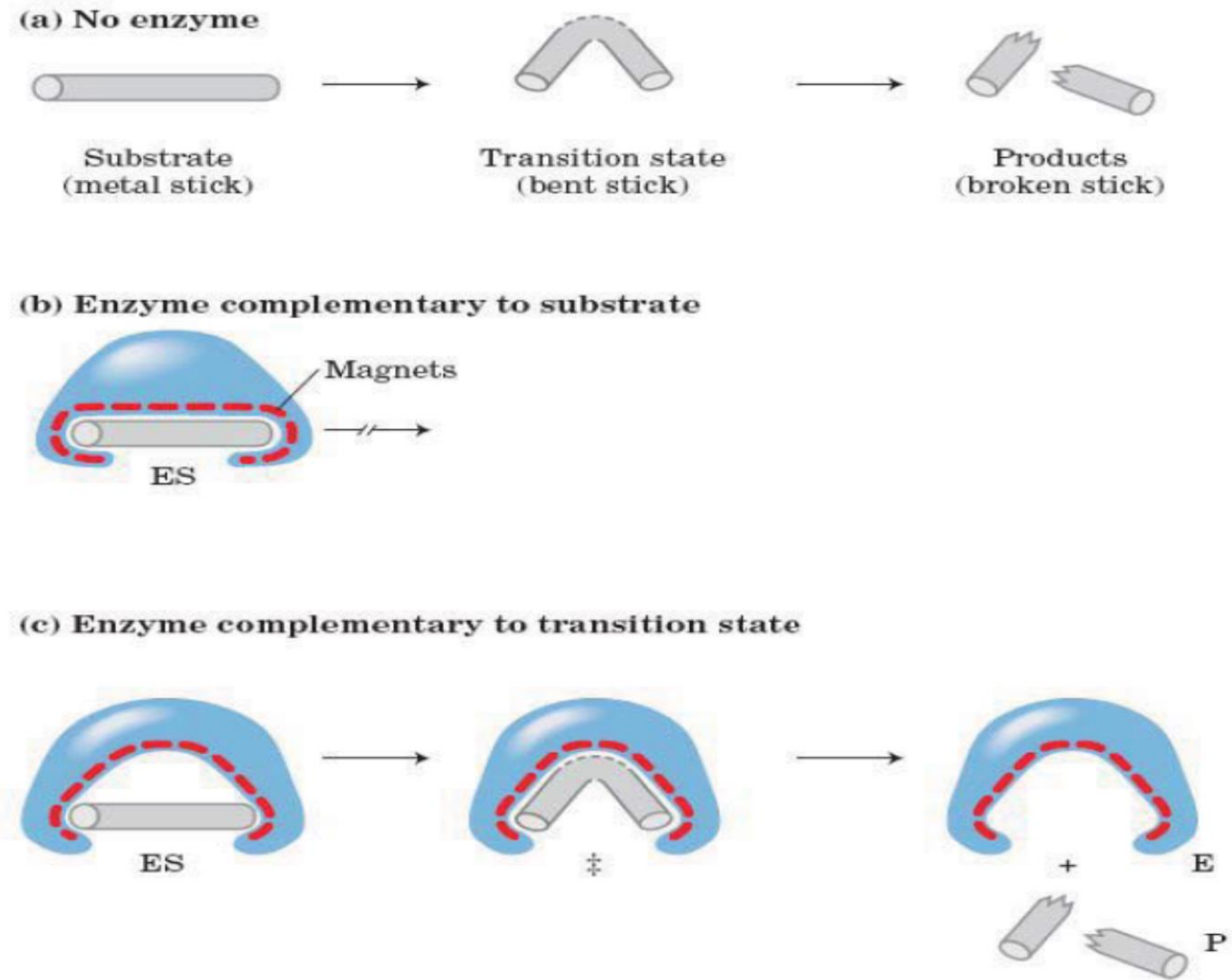
# مدل قفل و کلید فیشر:



# مدل غالب القايبي كوشلند:



# مدل جدید عملکرد آنزیم:



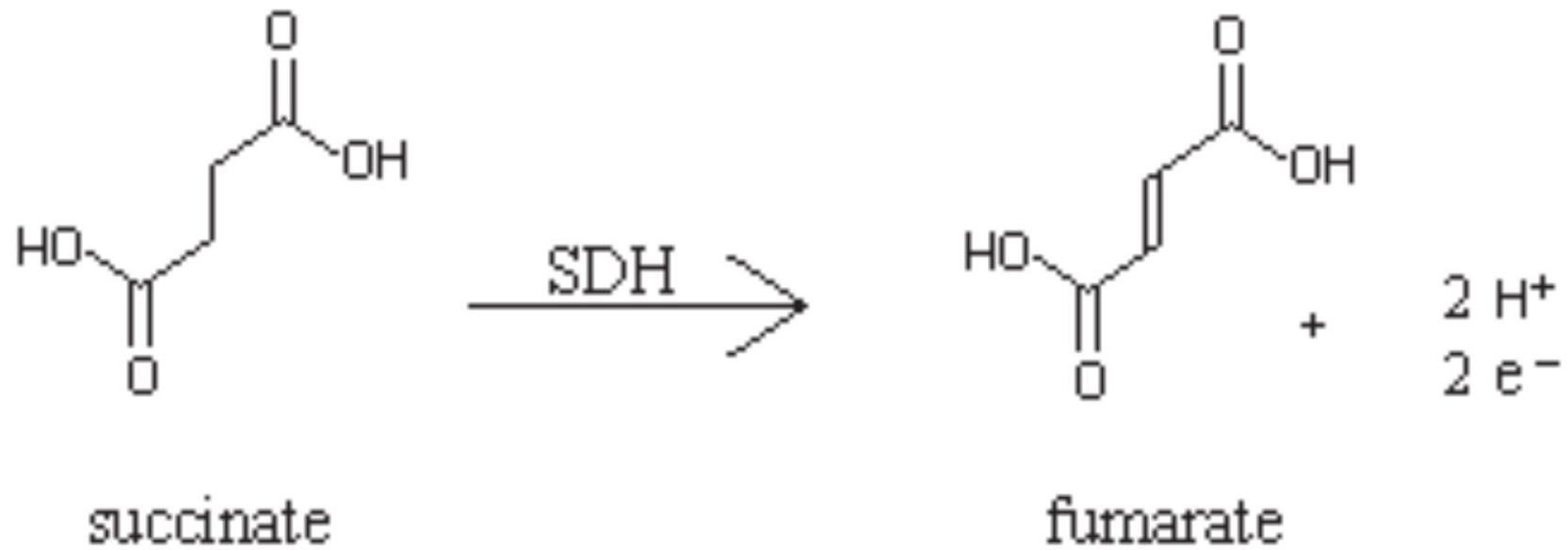
**FIGURE 6-5** An imaginary enzyme (stickase) designed to catalyze breakage of a metal stick.

# طبقه‌بندی آنزیم‌ها:

Class	Reaction type	Important subclasses
1 Oxidoreductases	<p>○ = Reduction equivalent</p> <p>A<sub>red</sub> + B<sub>ox</sub> ⇌ A<sub>ox</sub> + B<sub>red</sub></p>	Dehydrogenases Oxidases, peroxidases Reductases Monooxygenases Dioxygenases
2 Transferases	<p>A-B + C ⇌ A + B-C</p>	C <sub>1</sub> -Transferases Glycosyltransferases Amino transferases Phosphotransferases
3 Hydrolases	<p>A-B + H<sub>2</sub>O ⇌ A-H + B-OH</p>	Esterases Glycosidases Peptidases Amidases
4 Lyases ("synthases")	<p>A + B ⇌ A-B</p>	C-C-Lyases C-O-Lyases C-N-Lyases C-S-Lyases
5 Isomerases	<p>A ⇌ Iso-A</p>	Epimerases <i>cis trans</i> Isomerases Intramolecular transferases
6 Ligases ("synthetases")	<p>B + A + XTP ⇌ A-B + XDP</p> <p>X = A, G, U, C</p>	C-C-Ligases C-O-Ligases C-N-Ligases C-S-Ligases

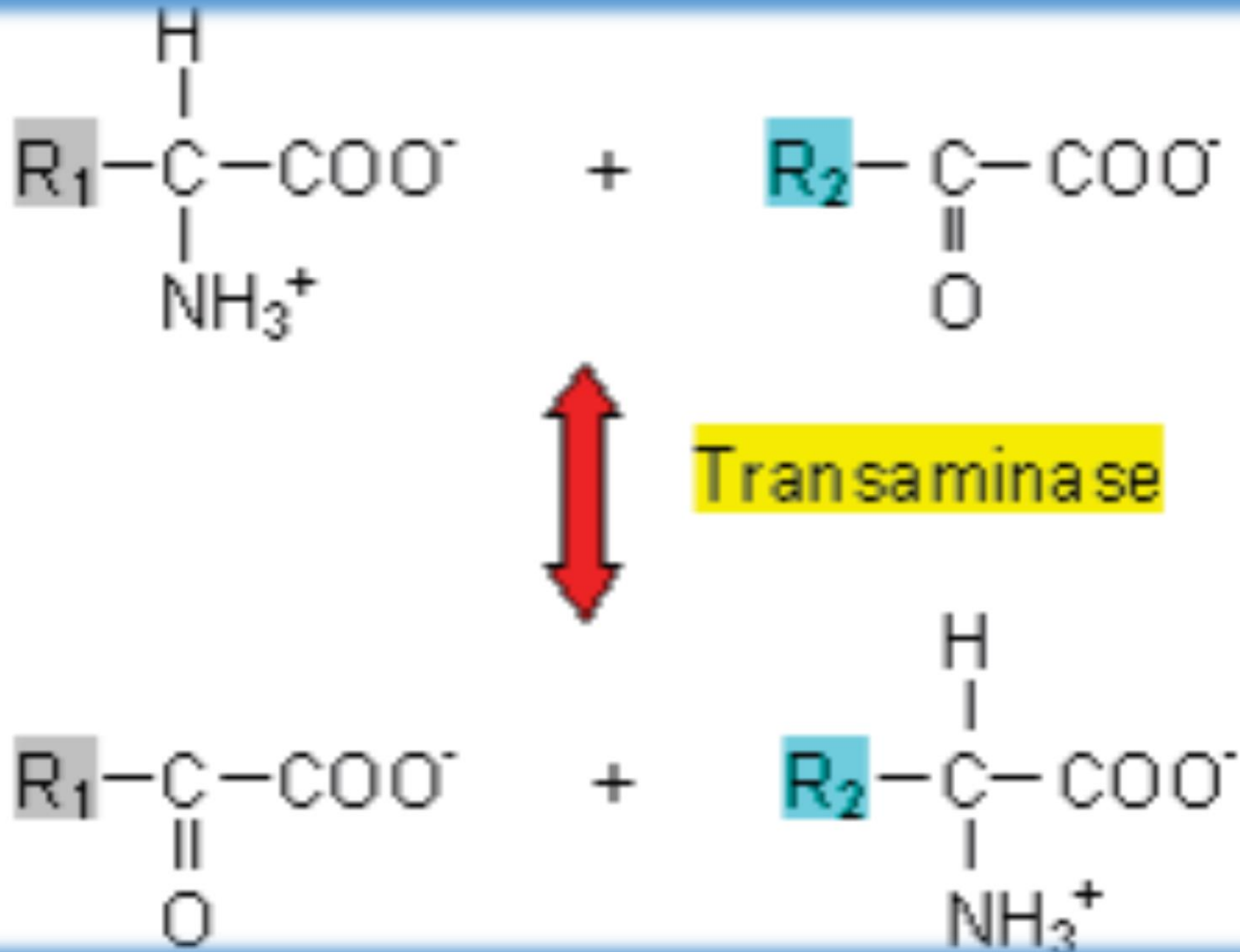


## اکسیدوردوکتازها:

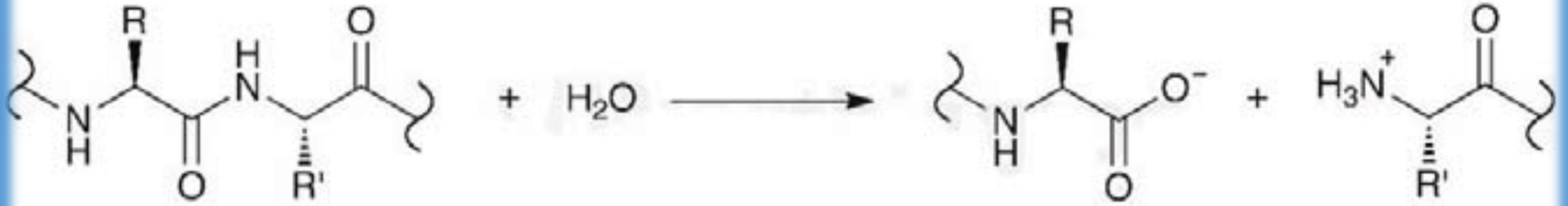


succinate dehydrogenase reaction

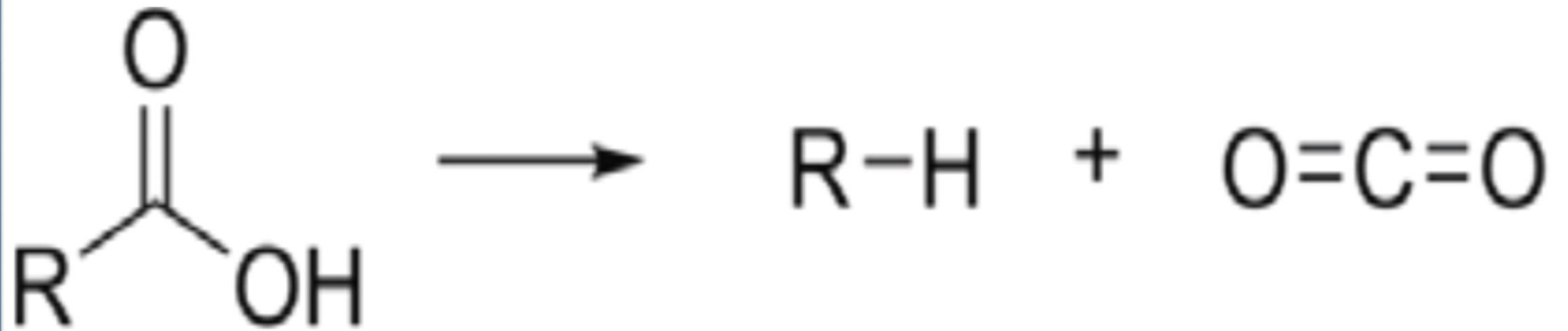
## ترانسفرازها:



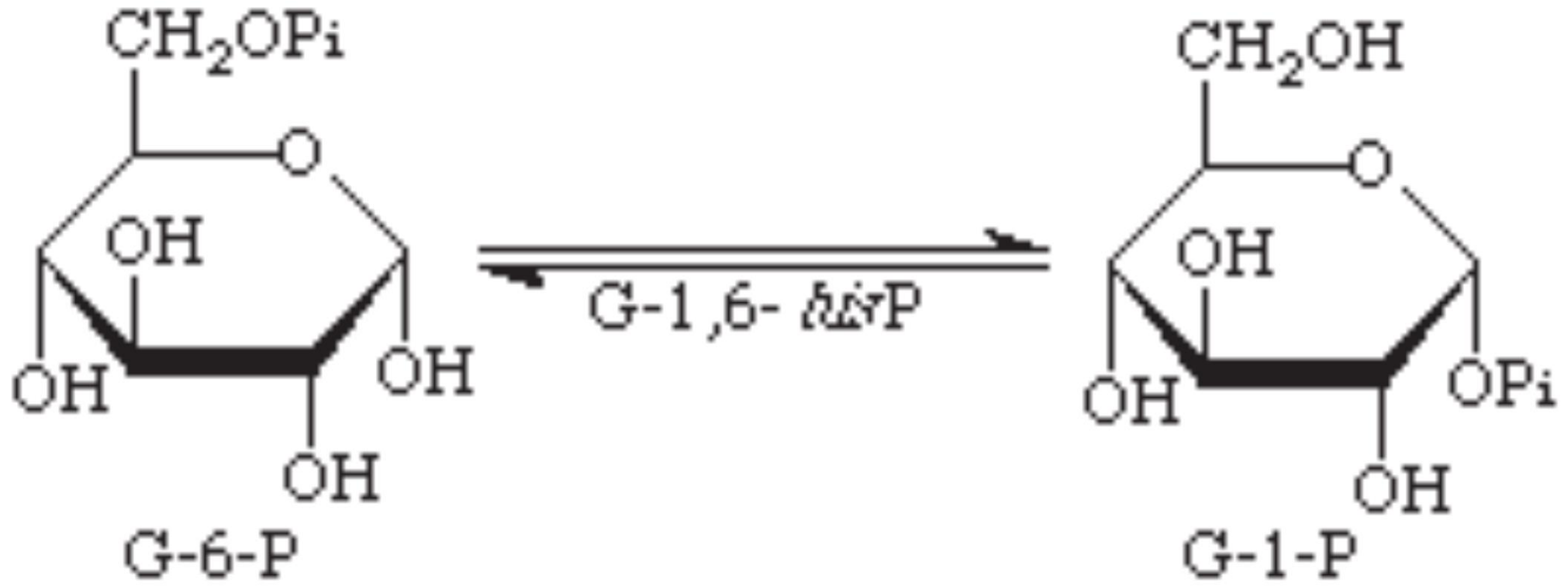
# هیدرولازها:



ليازها:



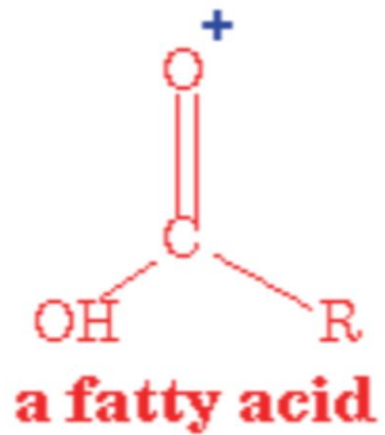
# ایزومرازها:



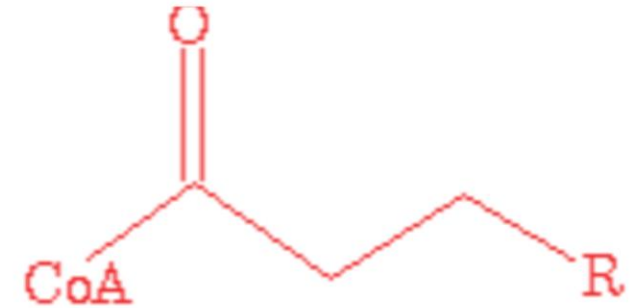


# لیگاژھا:

**Coenzyme A**



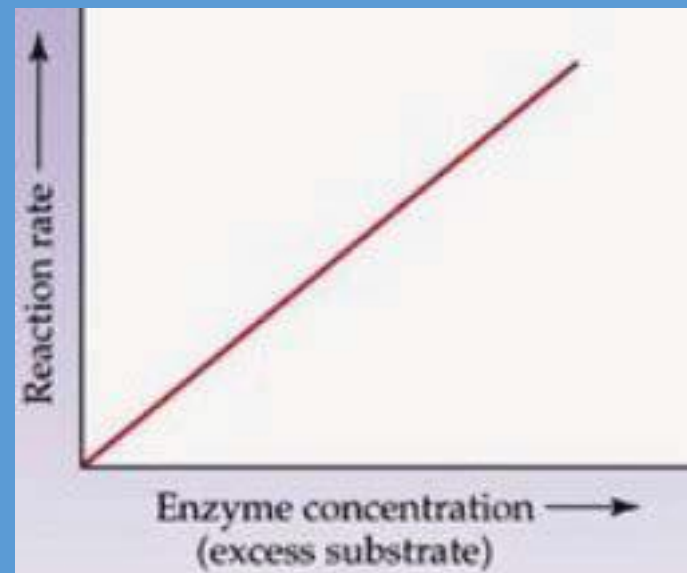
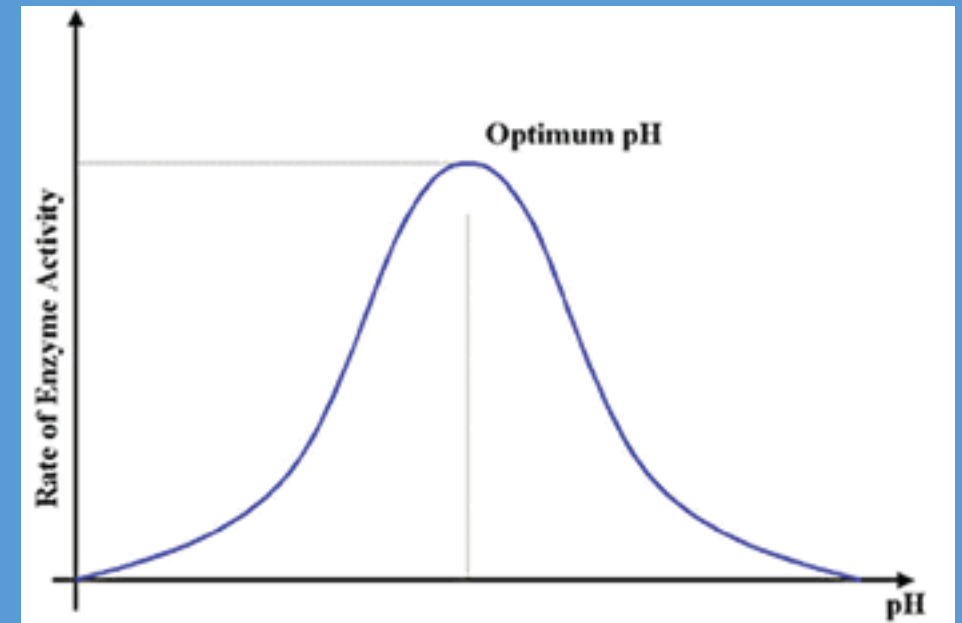
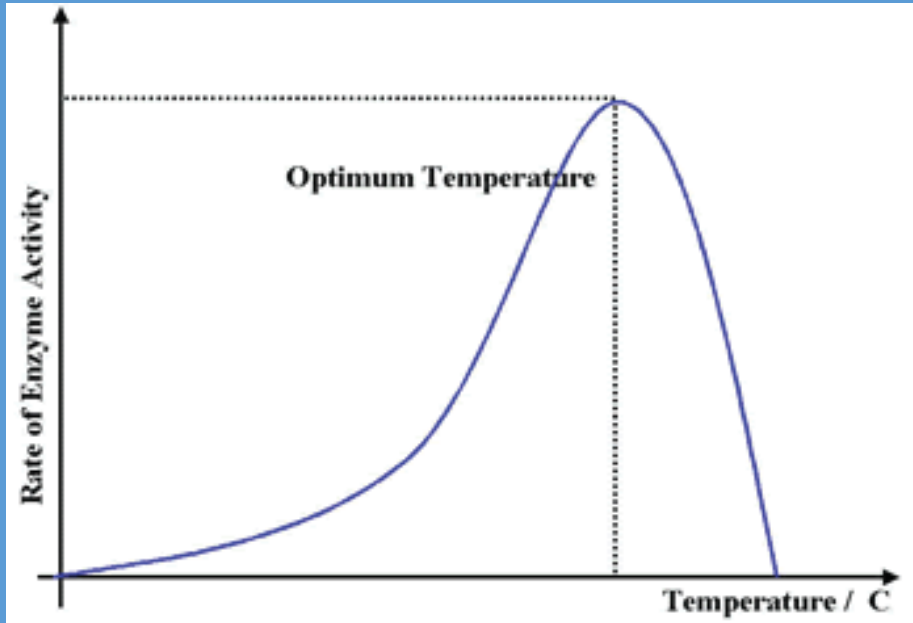
**+**  
**ATP**



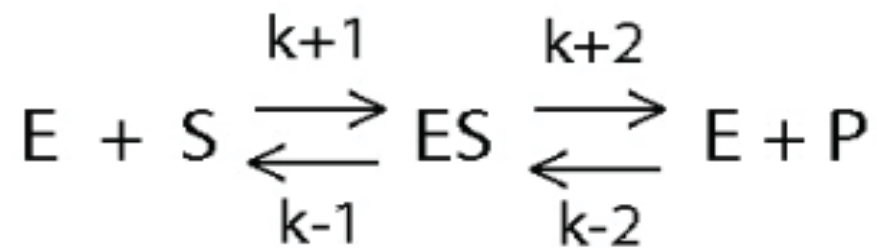
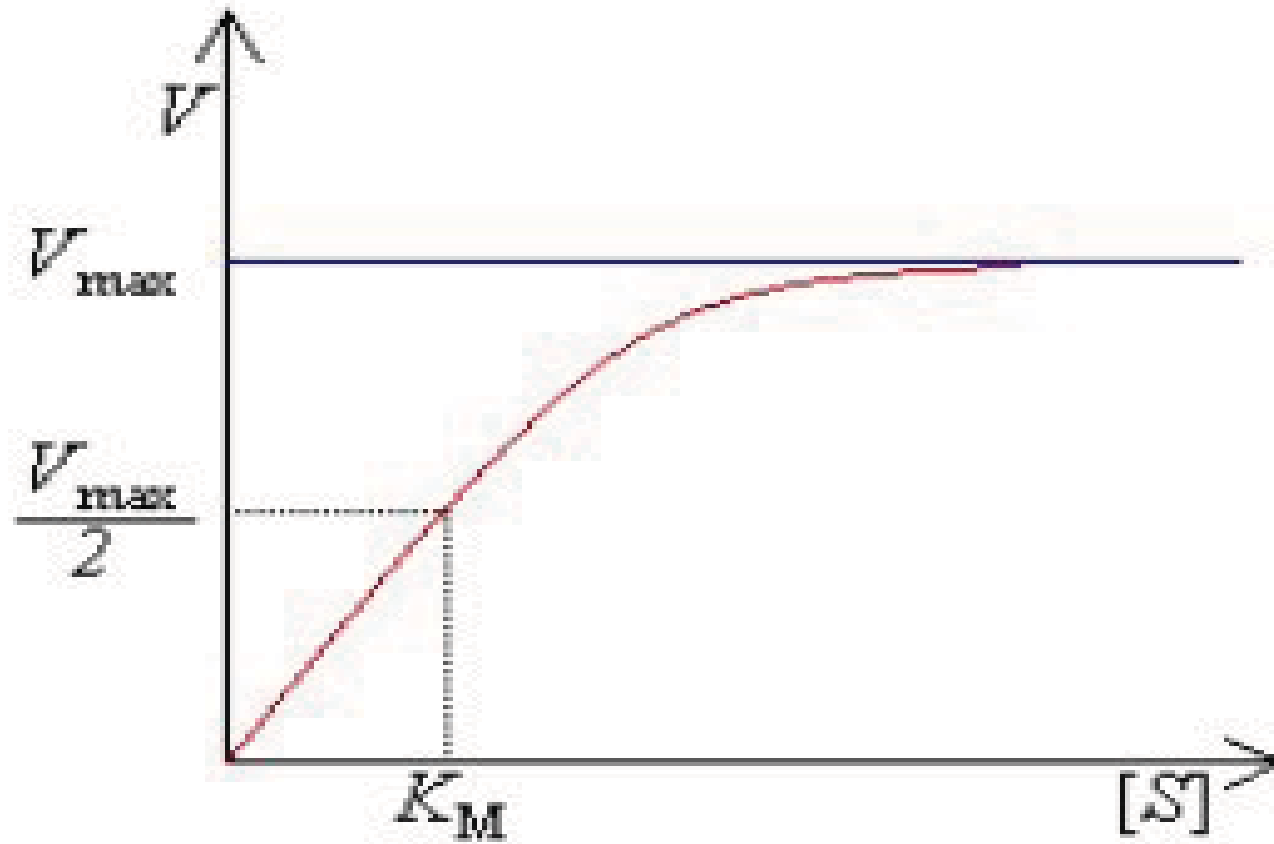
**+**  
**pyrophosphate**

**+**  
**AMP**

# سینتیک آنزیمی:

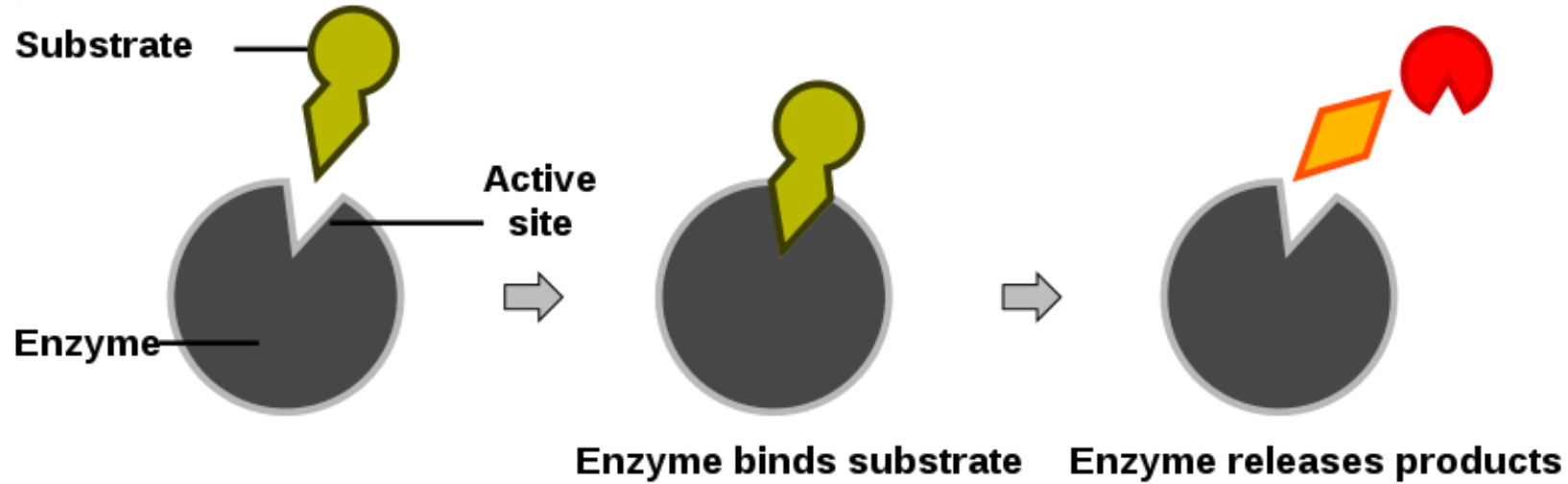


## معادله میکائلیس-منتن:

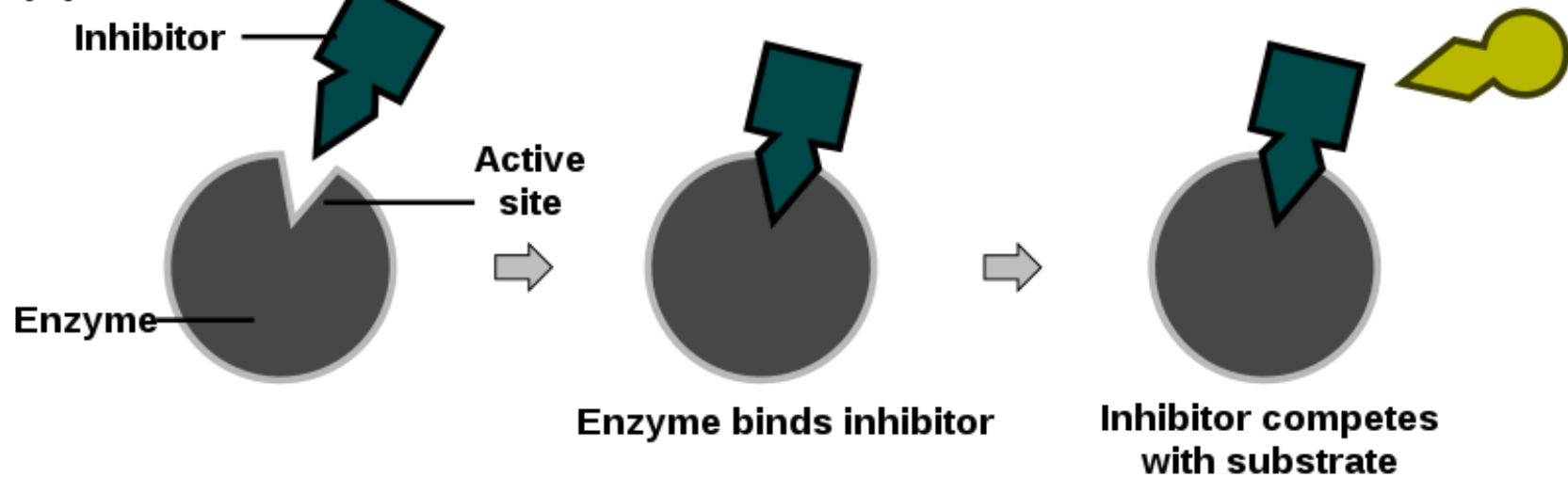


# مهارکننده‌های آنزیمی:

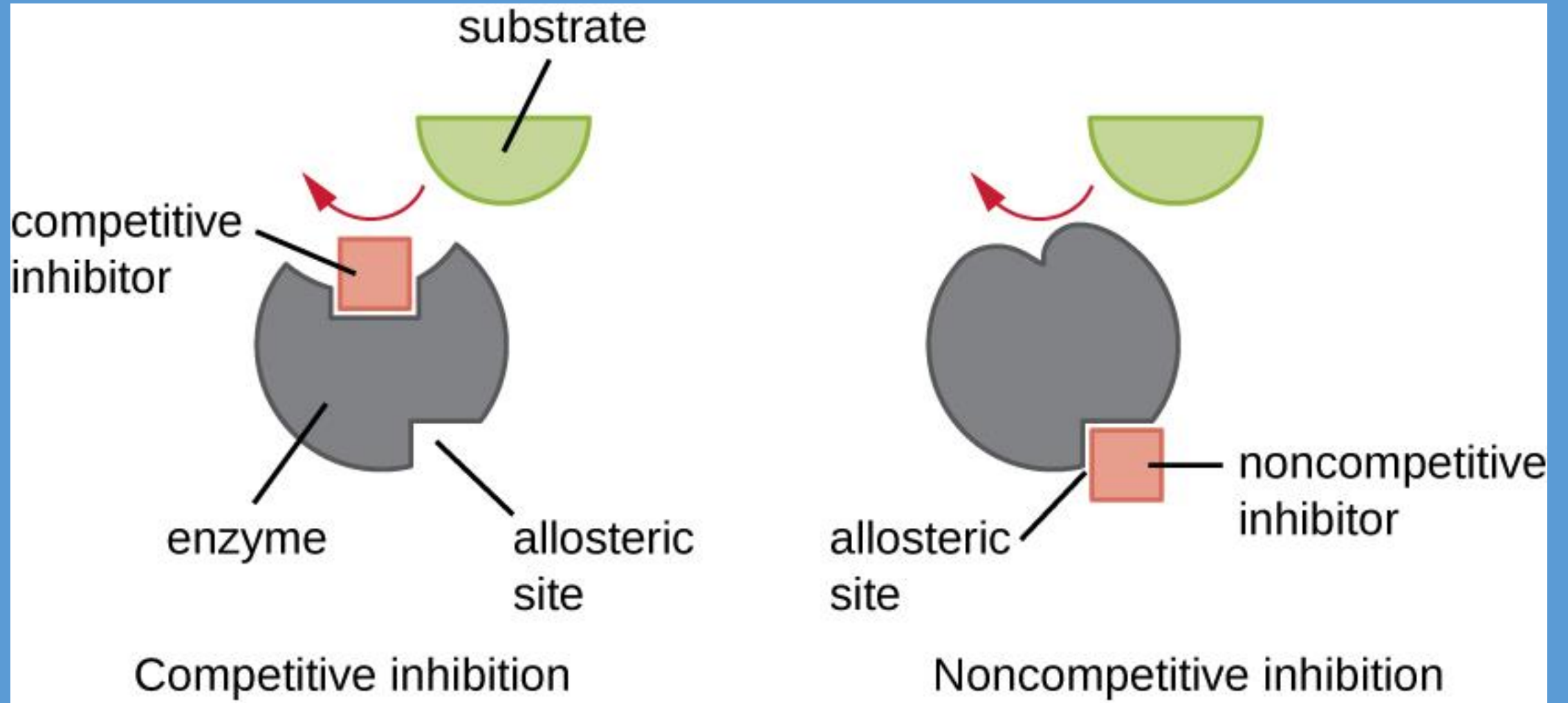
## (a) Reaction



## (b) Inhibition



# مهارکننده‌های برگشت پذیر:



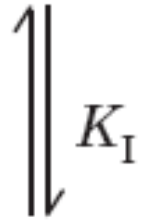
# مهارکننده‌های رقابتی:

## (a) Competitive inhibition

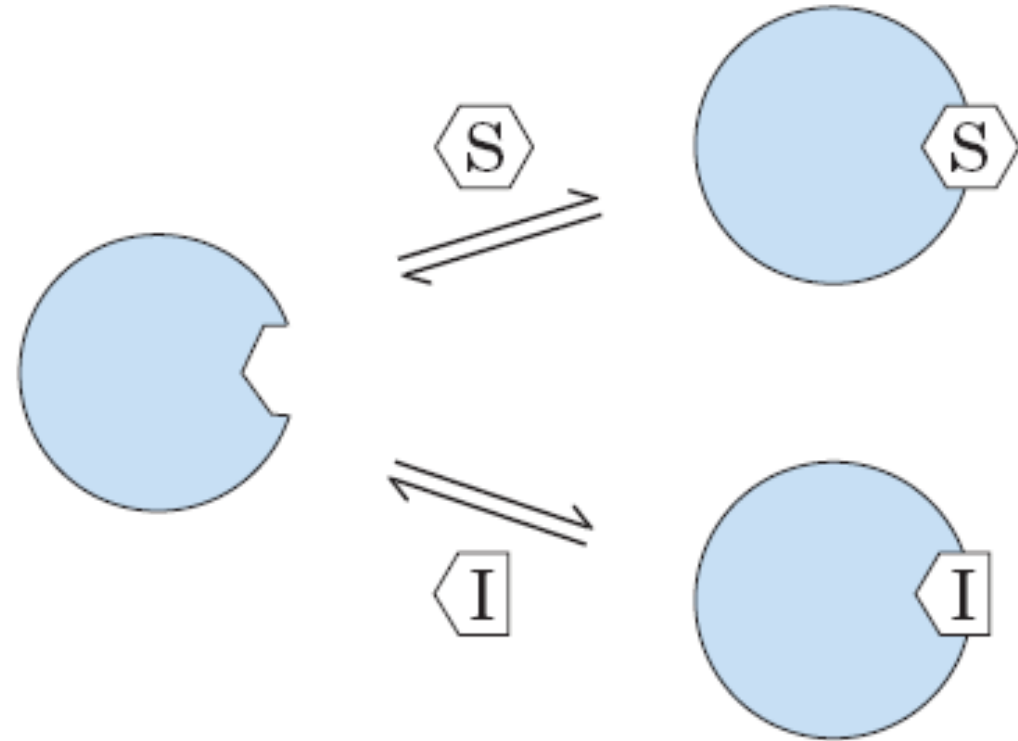


+

I

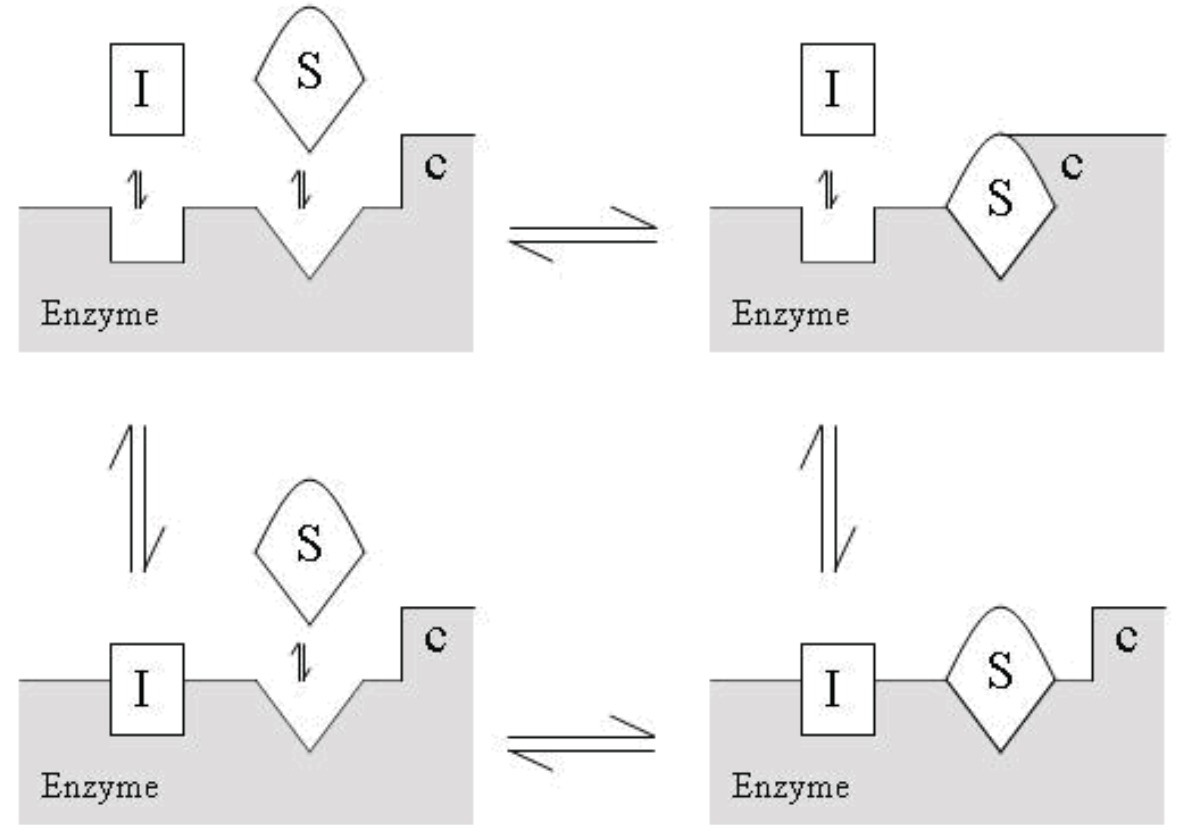
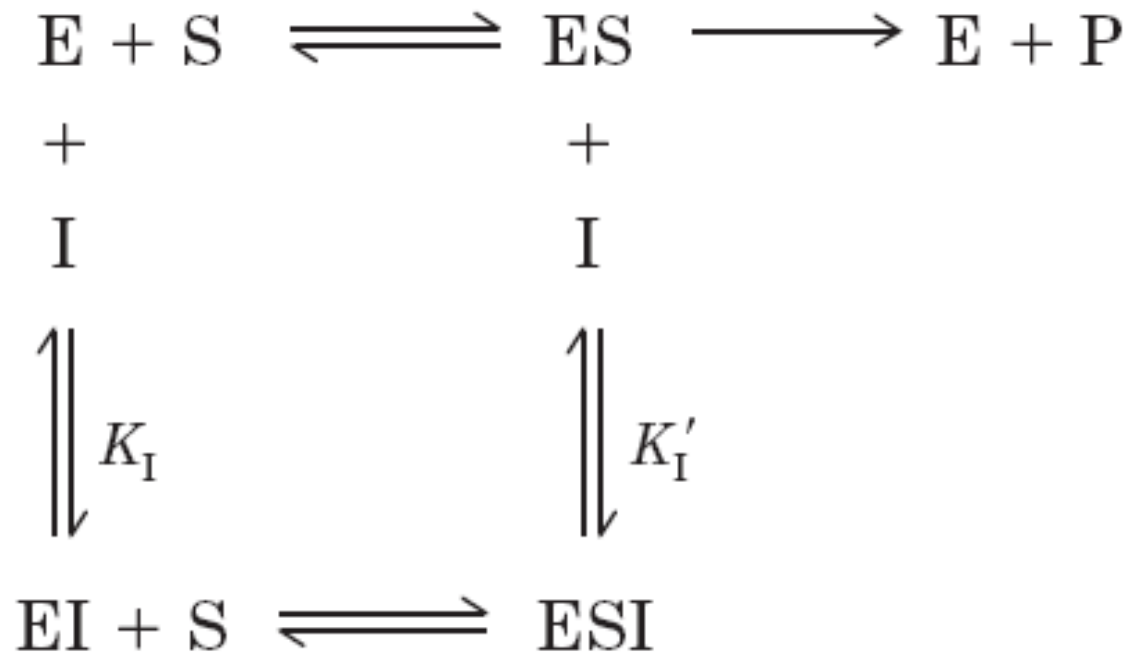


EI

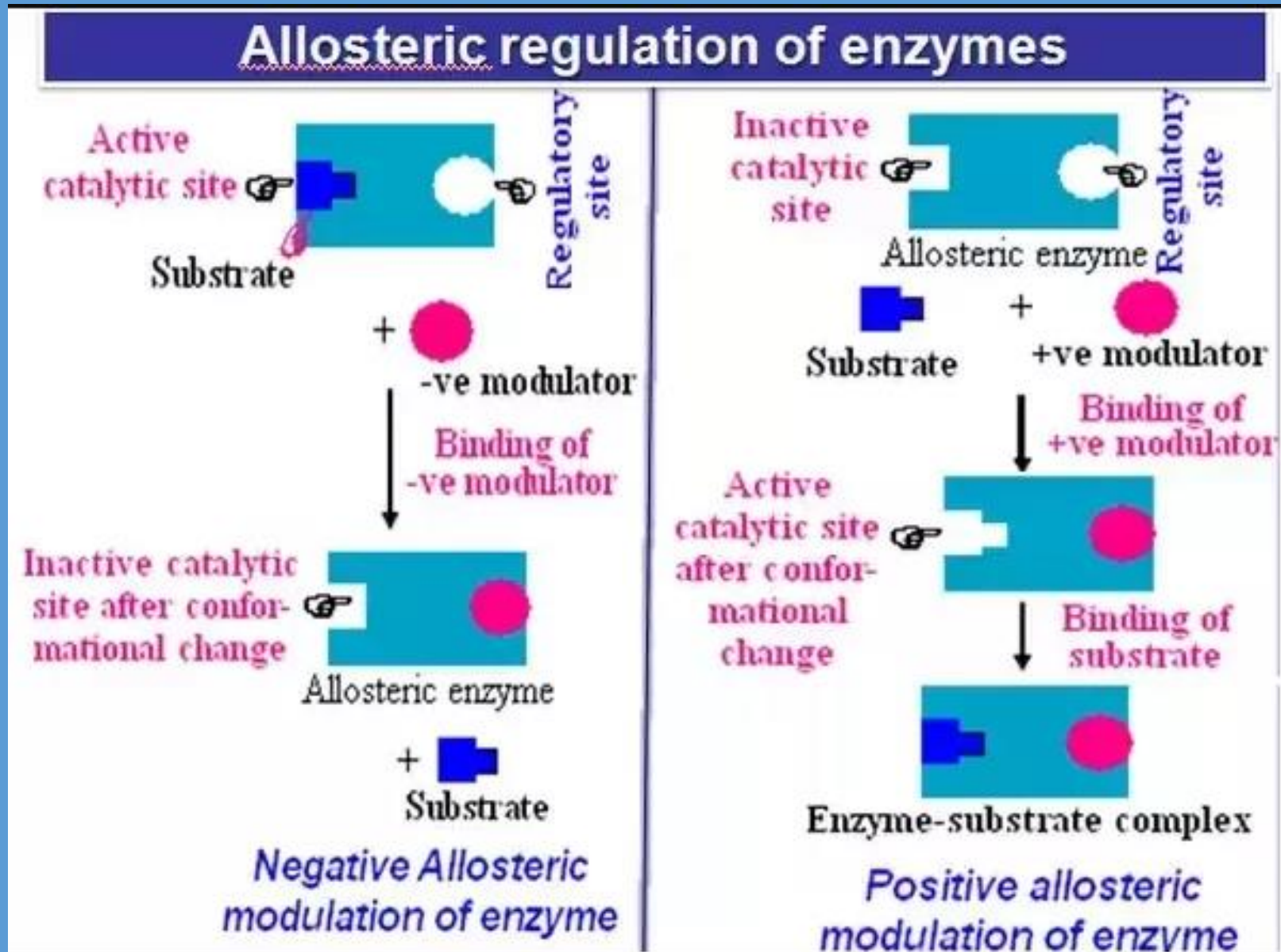




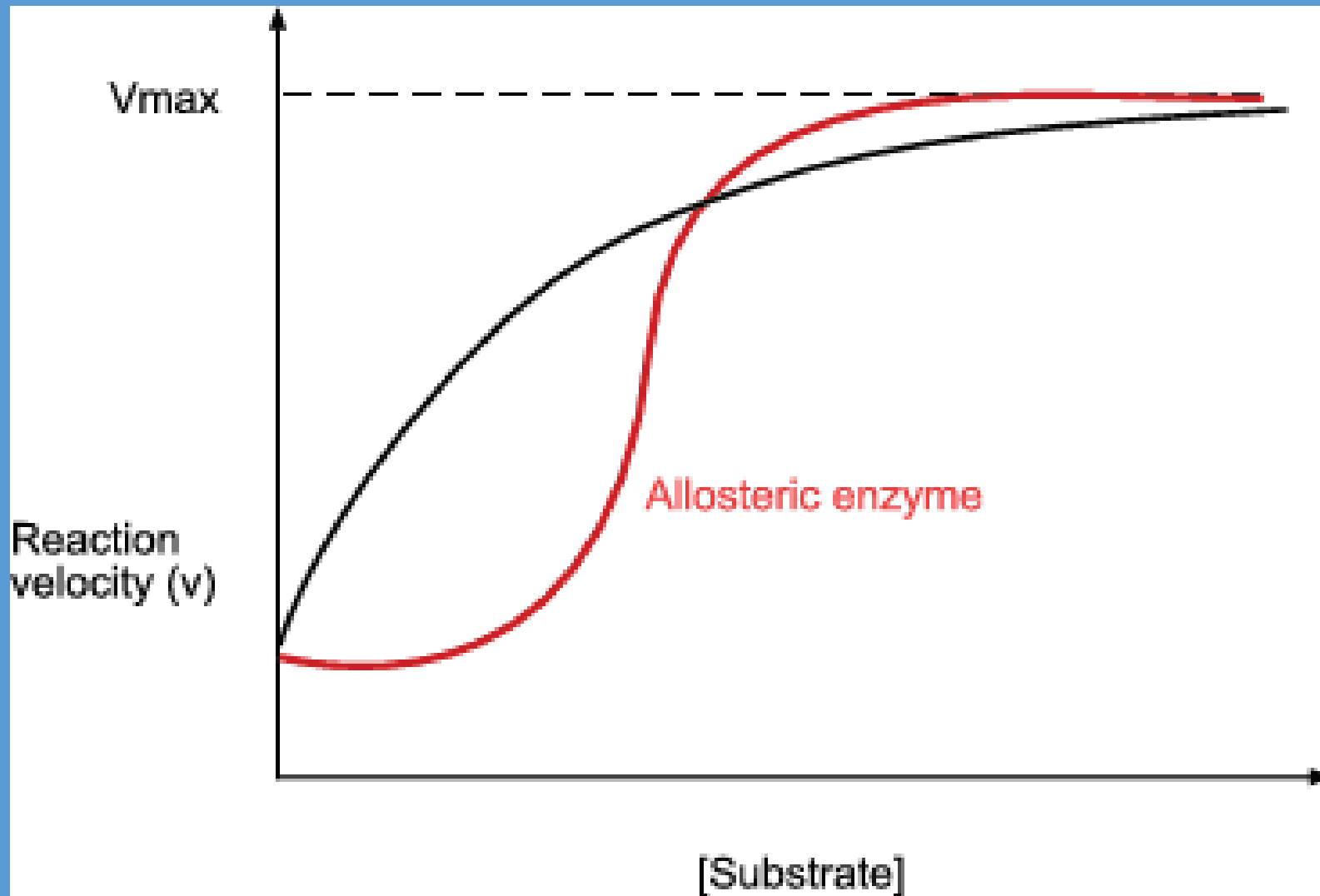
# مهارکننده‌های غیر رقابتی:



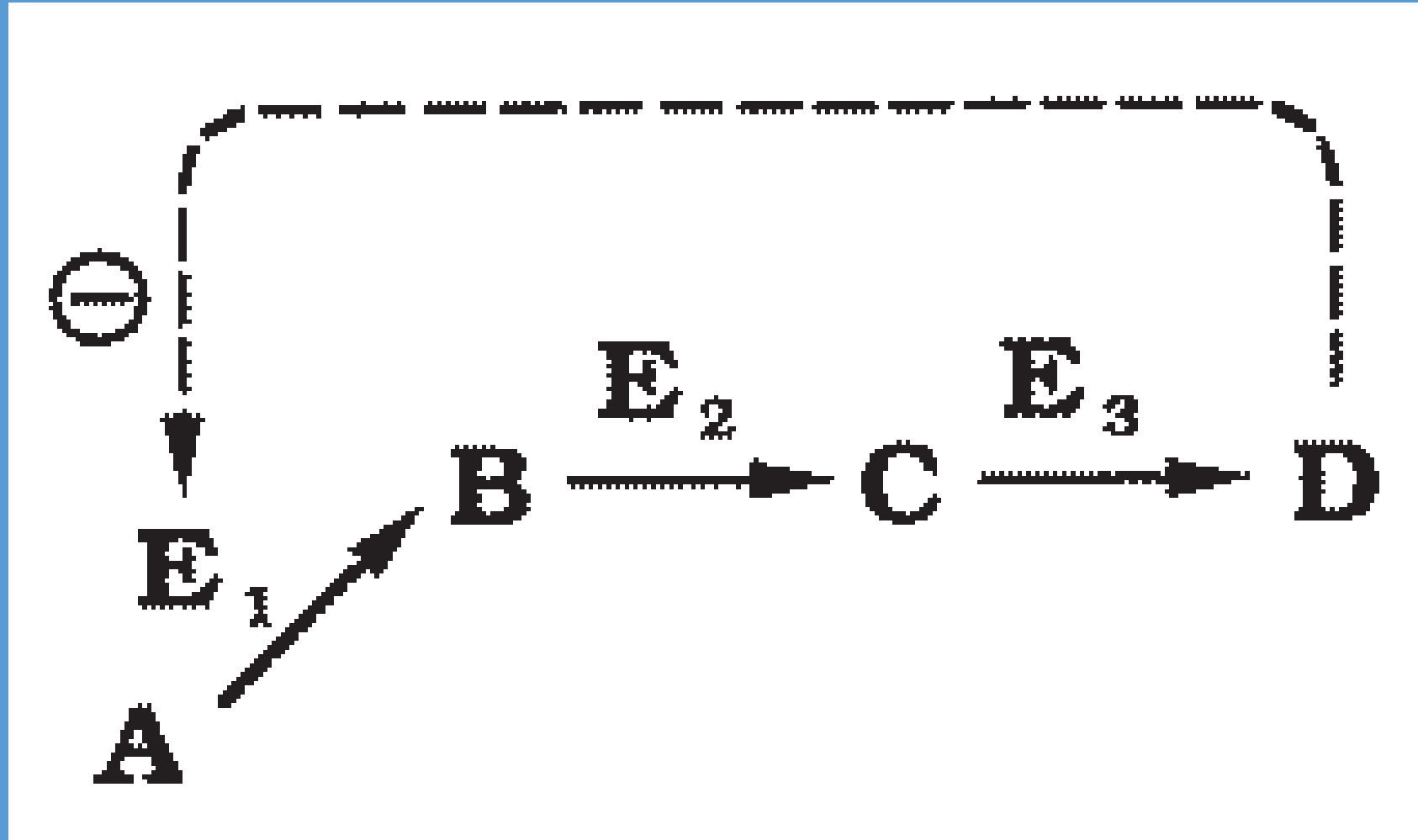
# آنزیم‌های آلوستریک:



# آنزیم‌های آلوستریک:

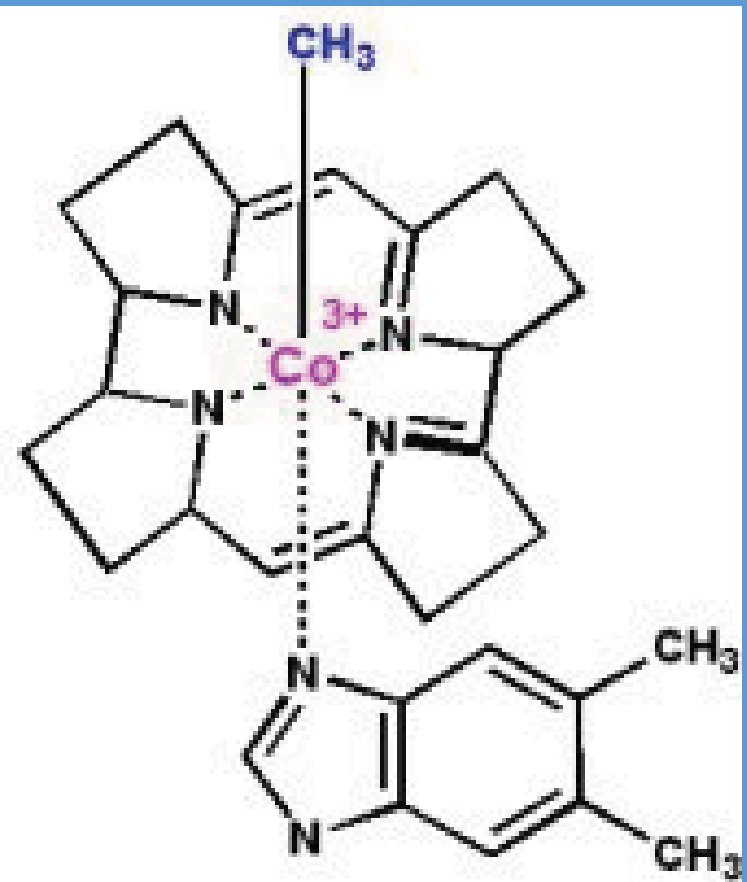


# آنزیم‌های آلوستریک و مهارفیدبکی:

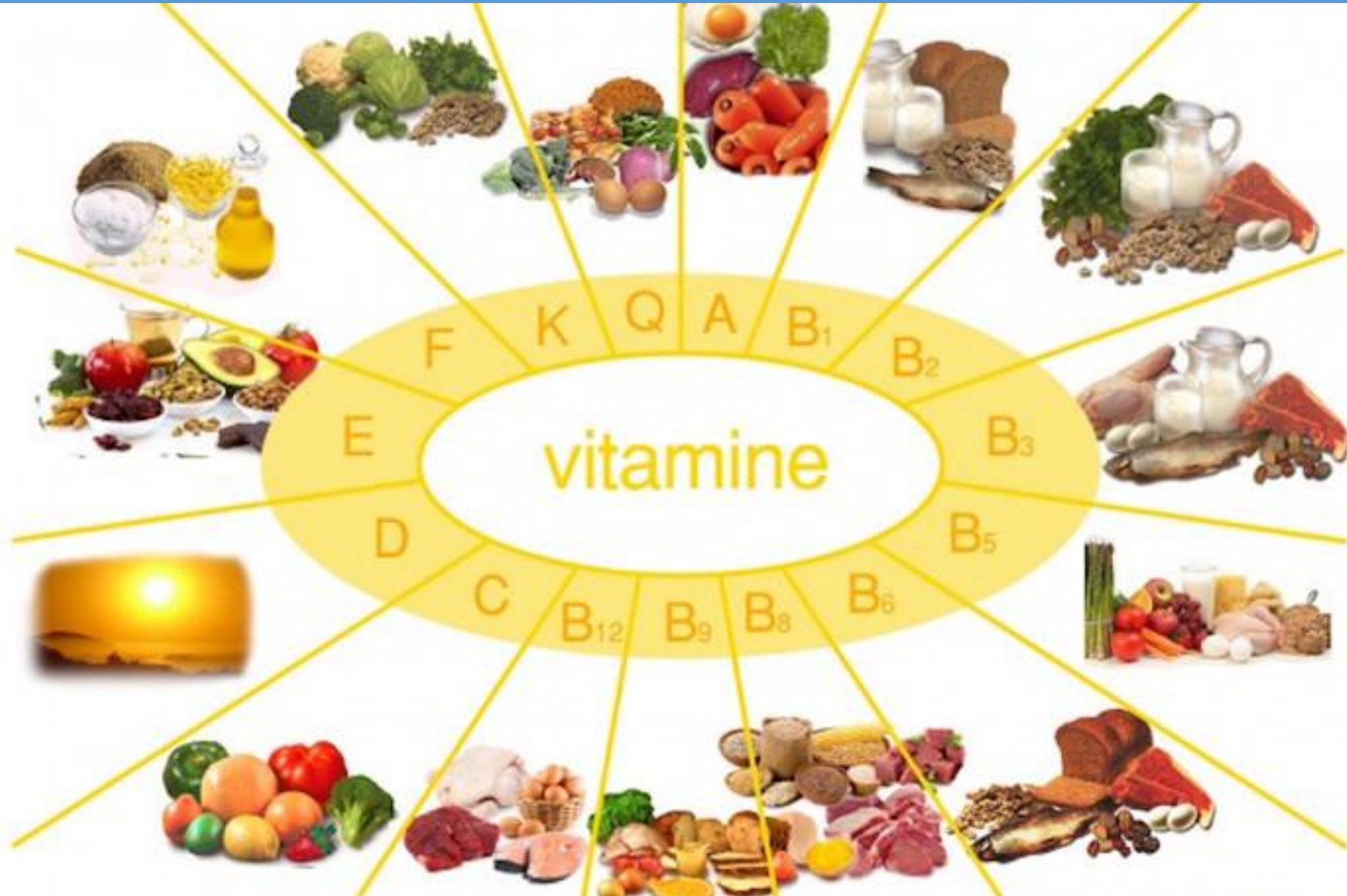


# ویتامین ها: ✓

- اهمیت
- ویژگی ها
- ساختمان شیمیایی

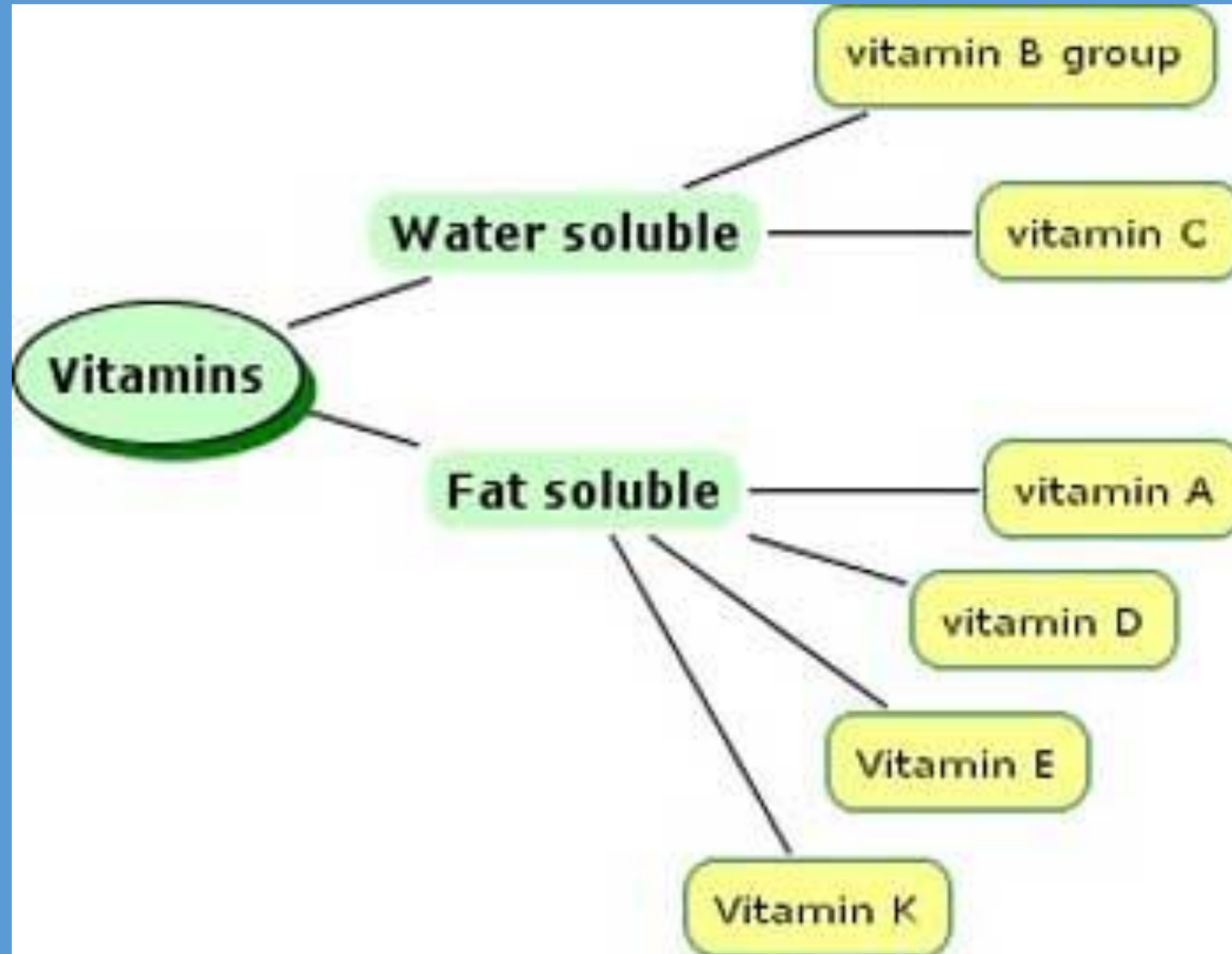


# ویتامین‌ها:

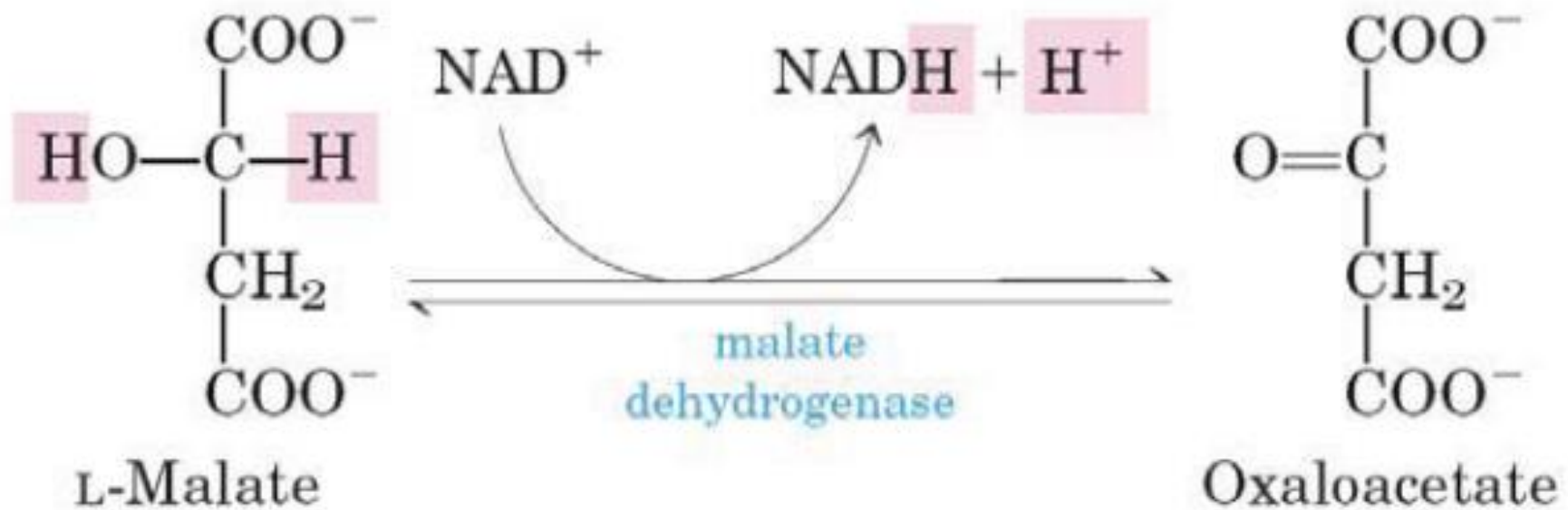




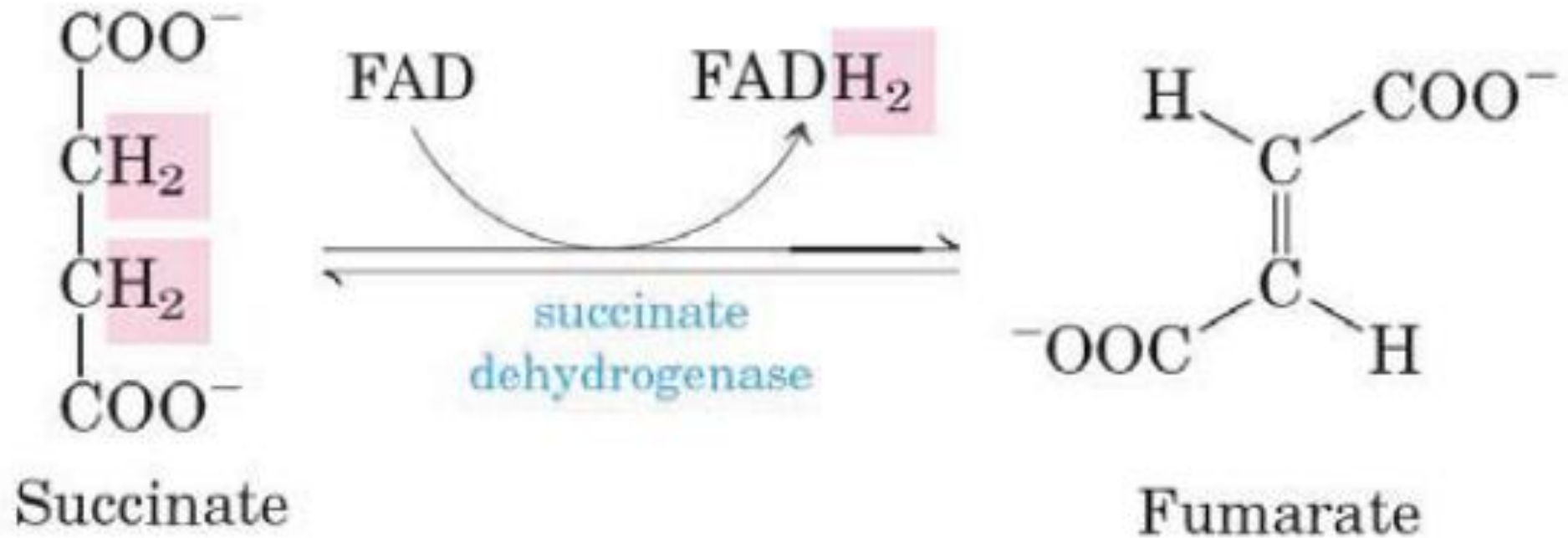
## تقسیم بندی ویتامین ها:



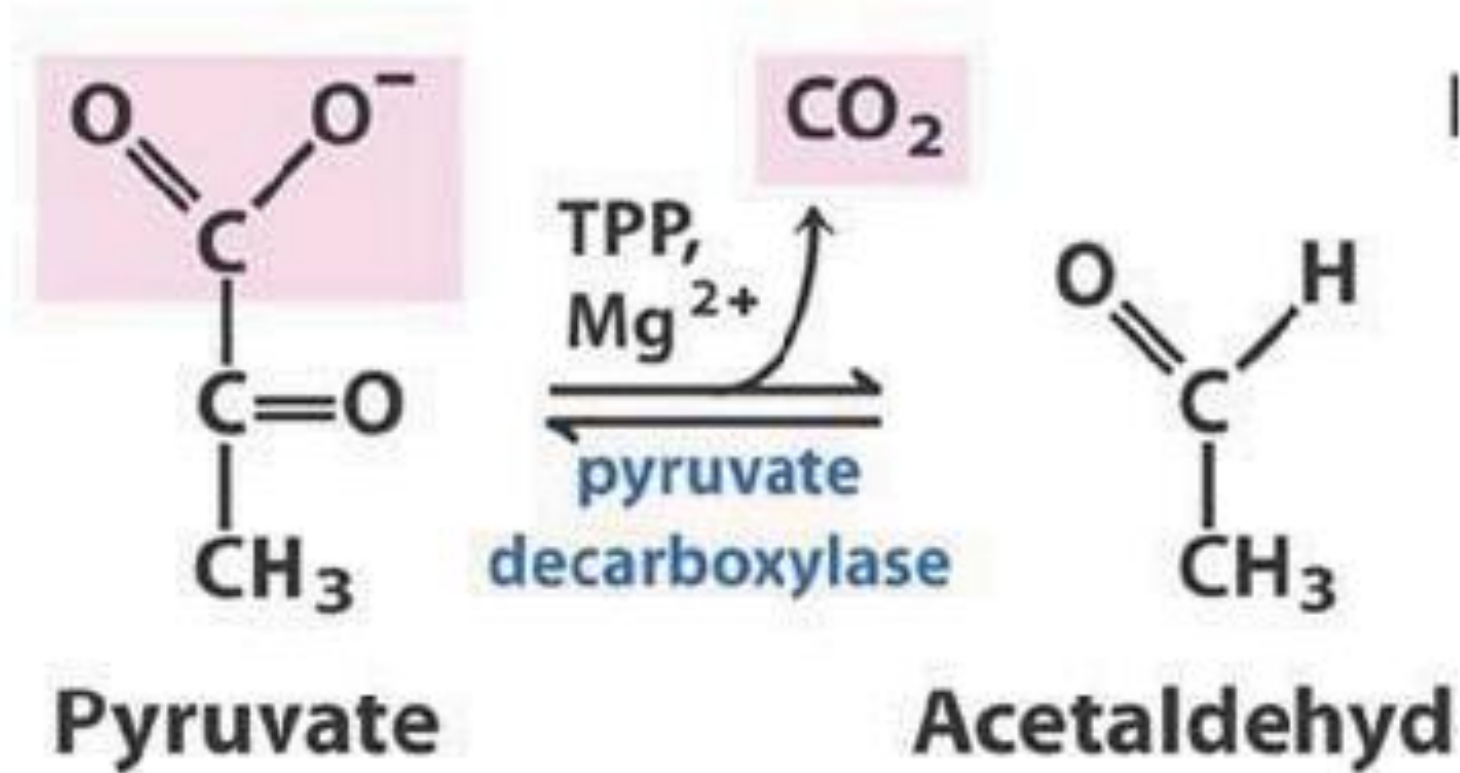
## ویتامین B3 (Niacin)



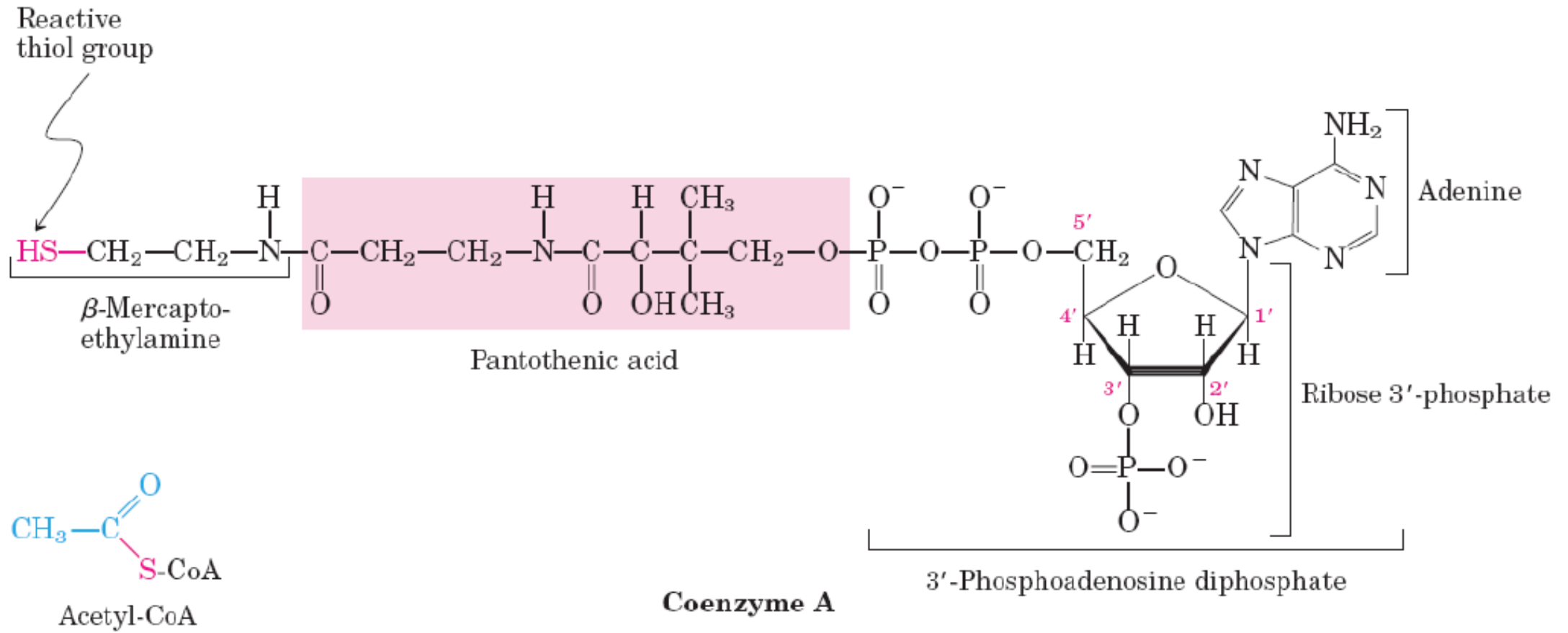
## ویتامین B2 (Riboflavin):



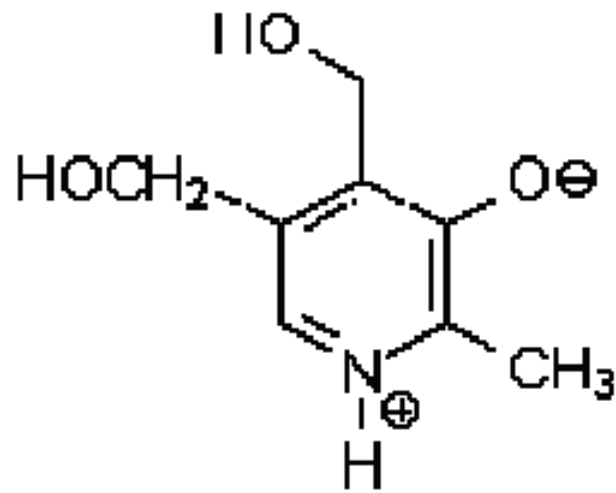
# ویتامین B1 (Thiamin):



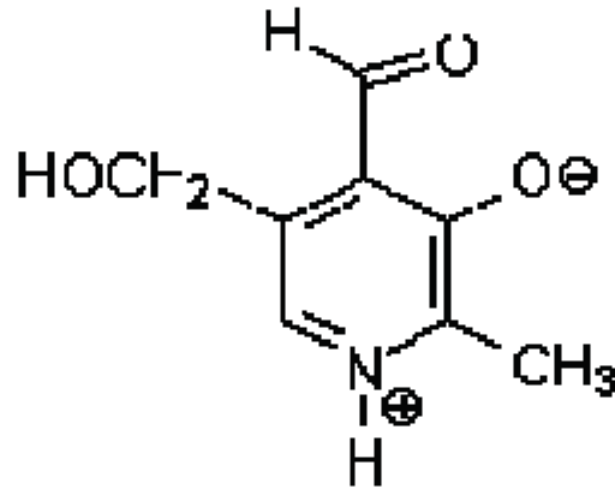
# :B5 (Pantothenic acid) ویتامین



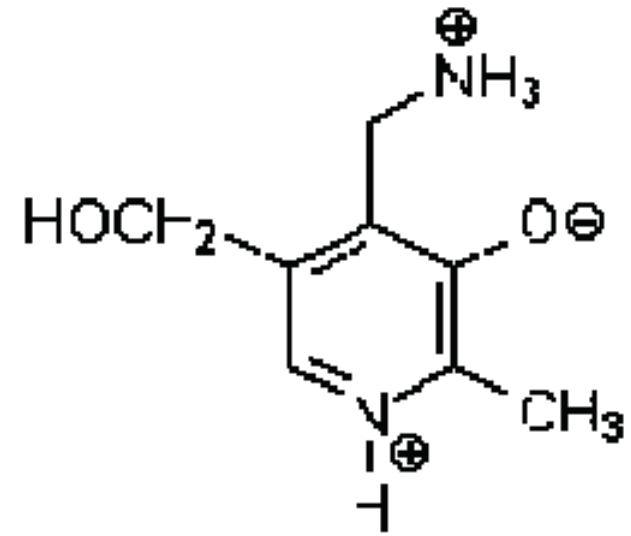
# ویتامین B6: B6



Pyridoxine



Pyridoxal

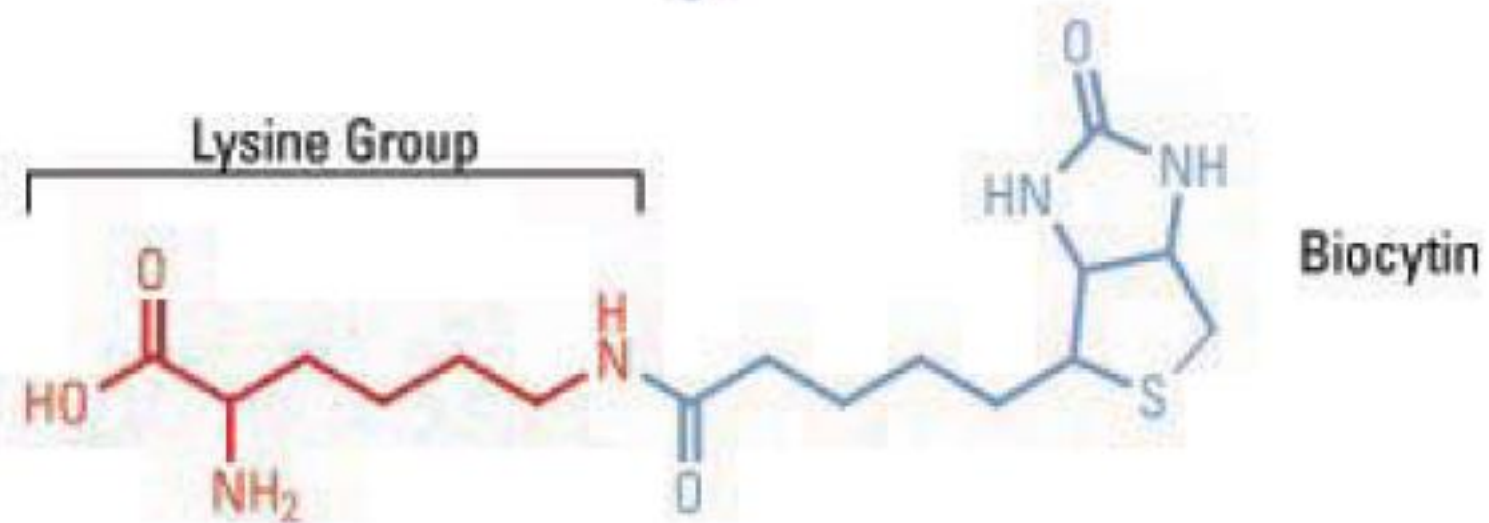
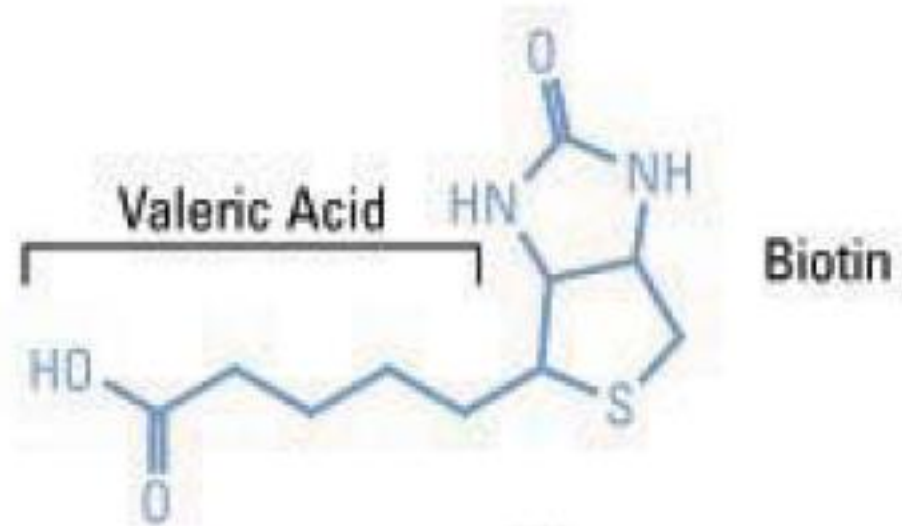


Pyridoxamine

Vitamin B<sub>6</sub>



# ویتامین (Biotin) :B7



# ویتامین B9 (Folic acid)

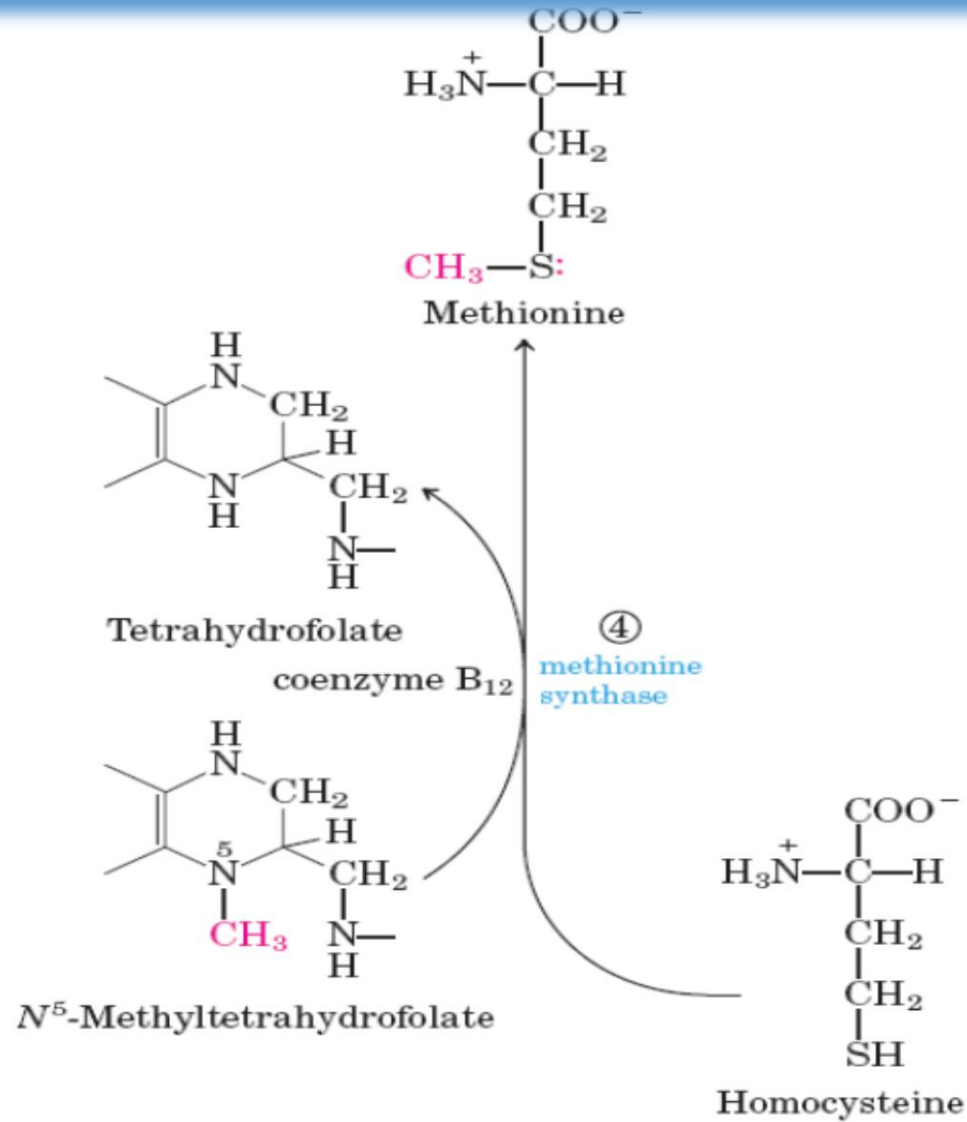
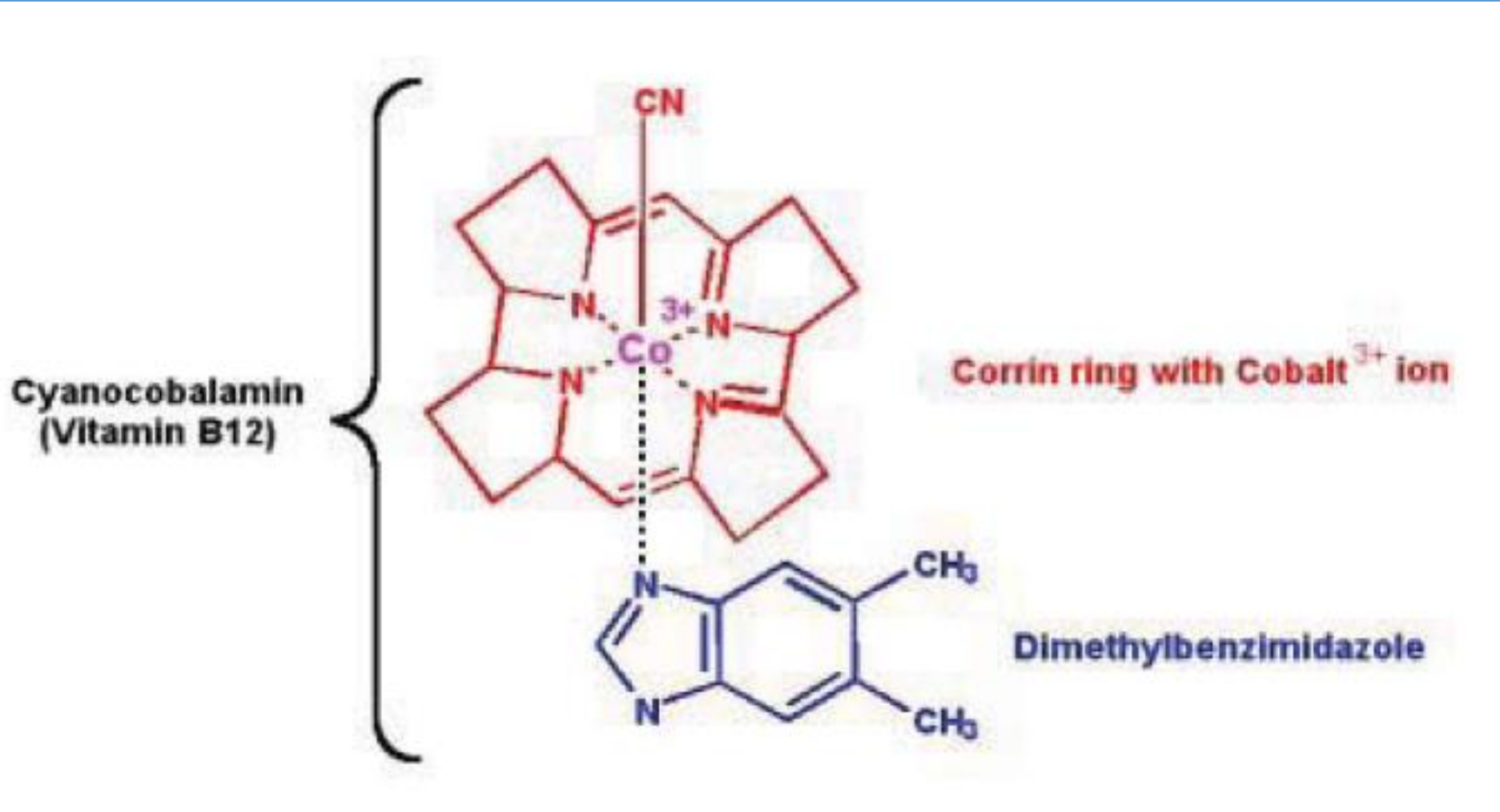


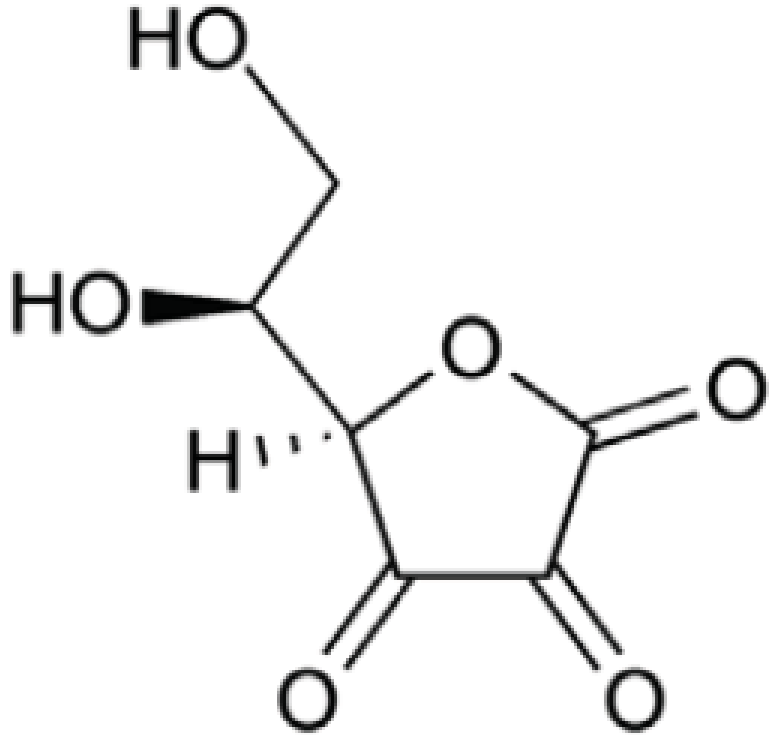
FIGURE 18-18 Synthesis of methionine

انتقال گروه متیل از متیل تتراهیدروفولات به هموسیستین و ساخته شدن متیونین

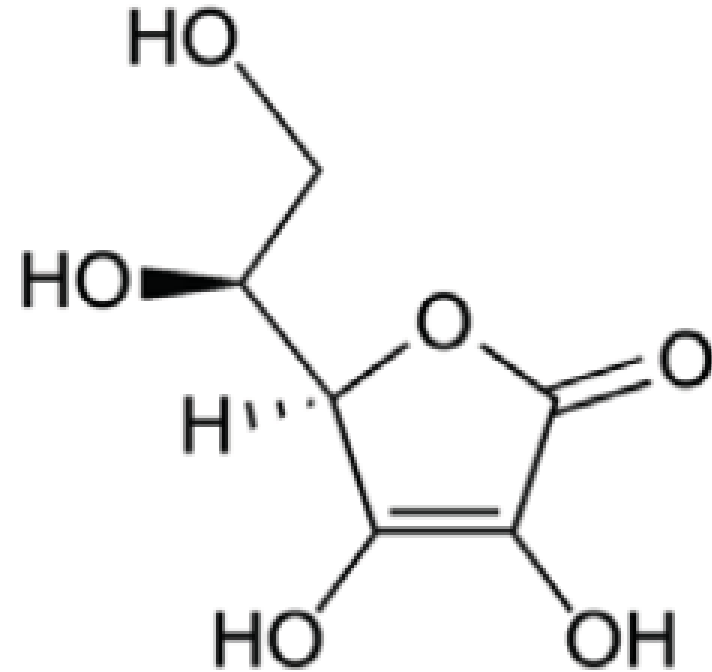
# ویتامین B12 (Cyanocobalamin)



# ویتامین C (Ascorbic acid):

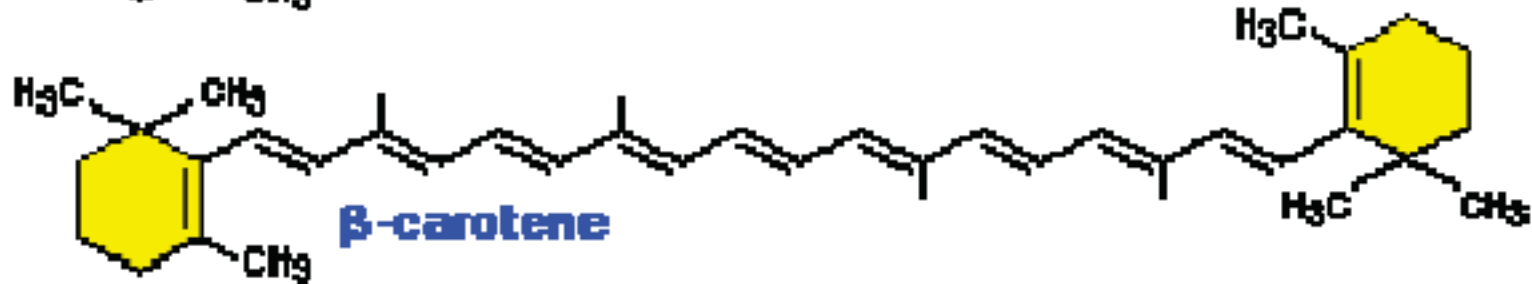
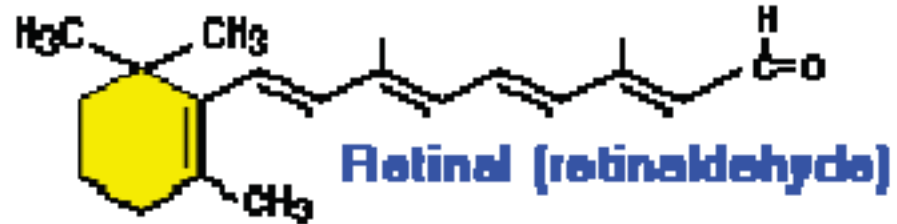


**Dehydro L-Ascorbic acid**

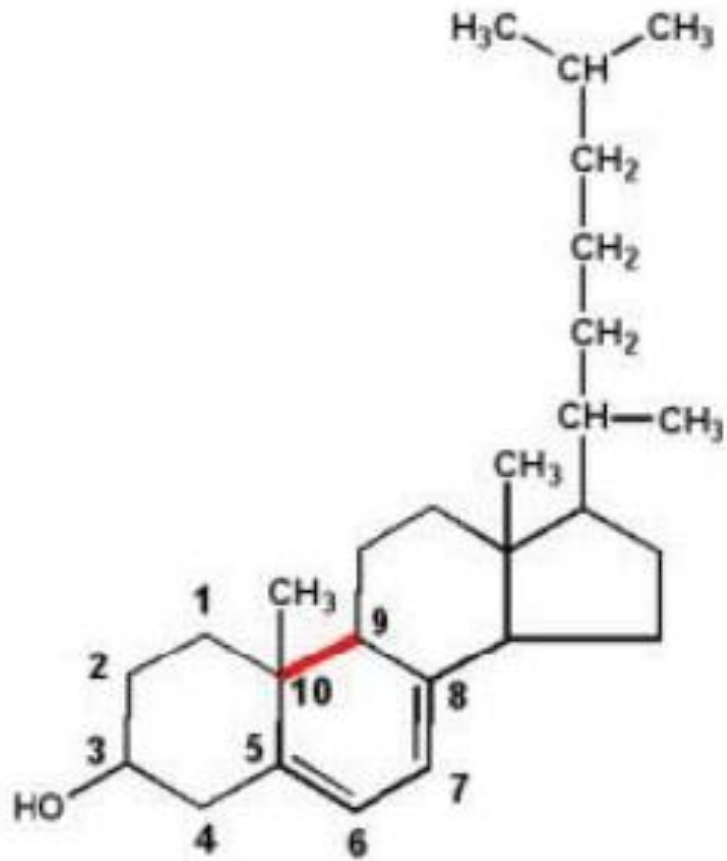


**L-Ascorbic acid (reduced form)**

# ویتامین A:

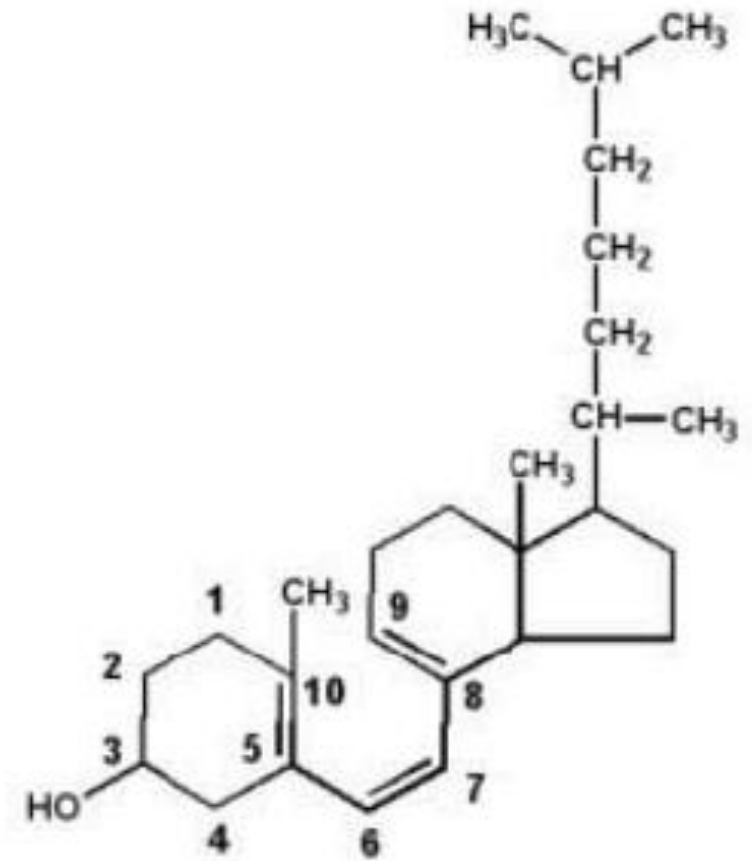


# ویتامین D:



7-Dehydrocholesterol

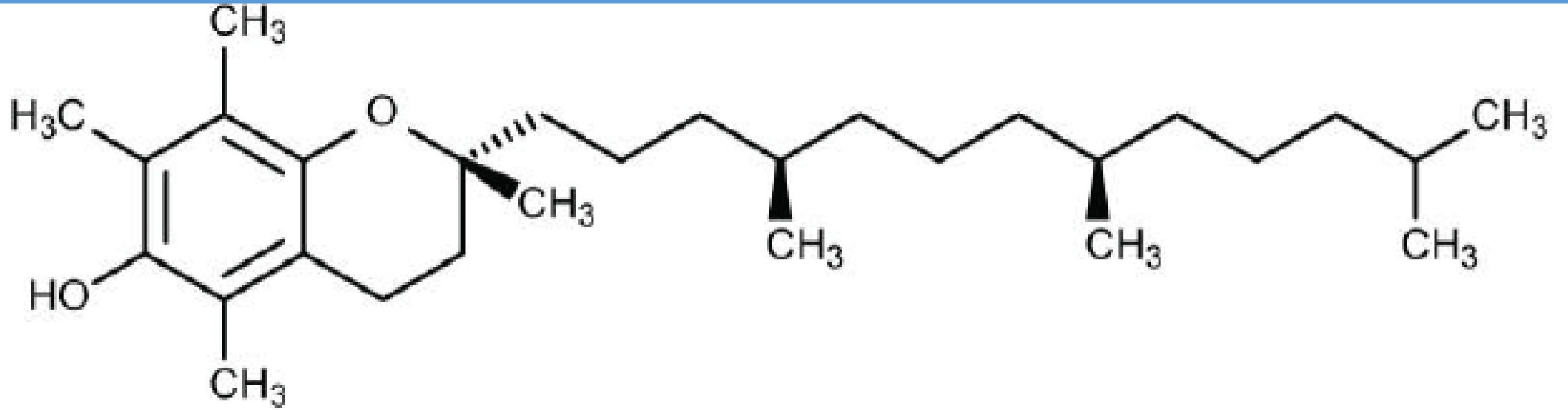
U.V. Light



Vitamin D



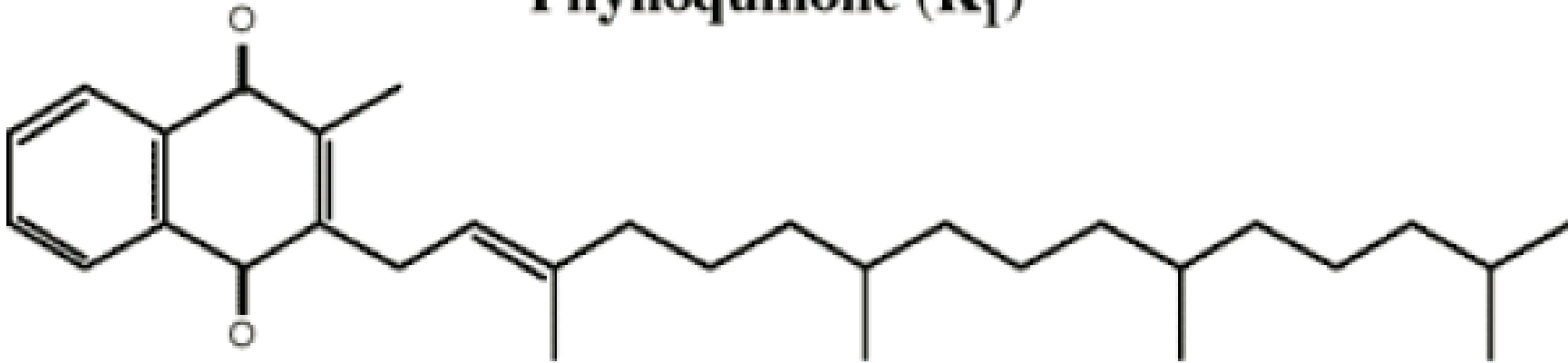
# ویتامین E:



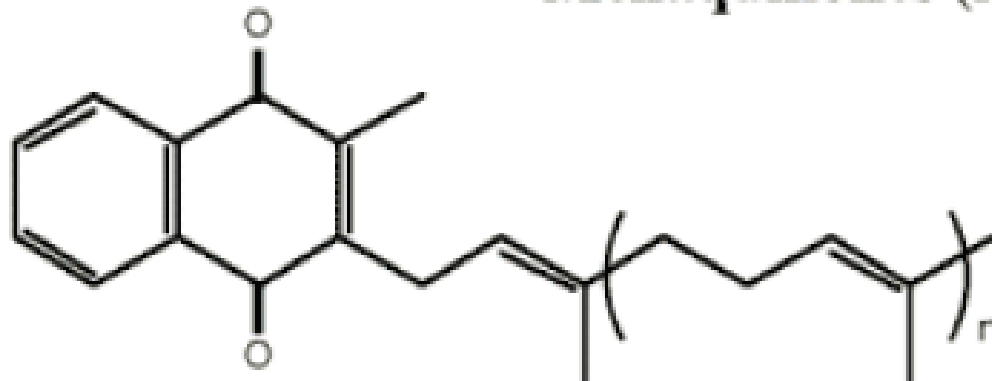
ساختار آلفا-توکوفرول

# ویتامین K:

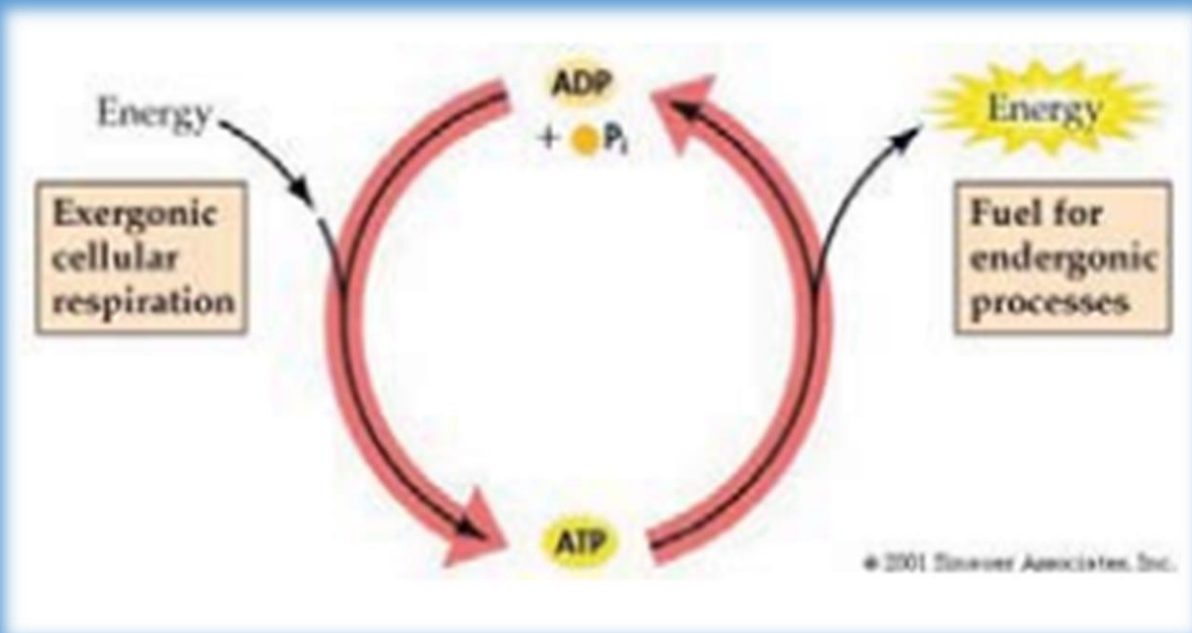
**Phylloquinone (K<sub>1</sub>)**



**Menaquinones (MK-n)**

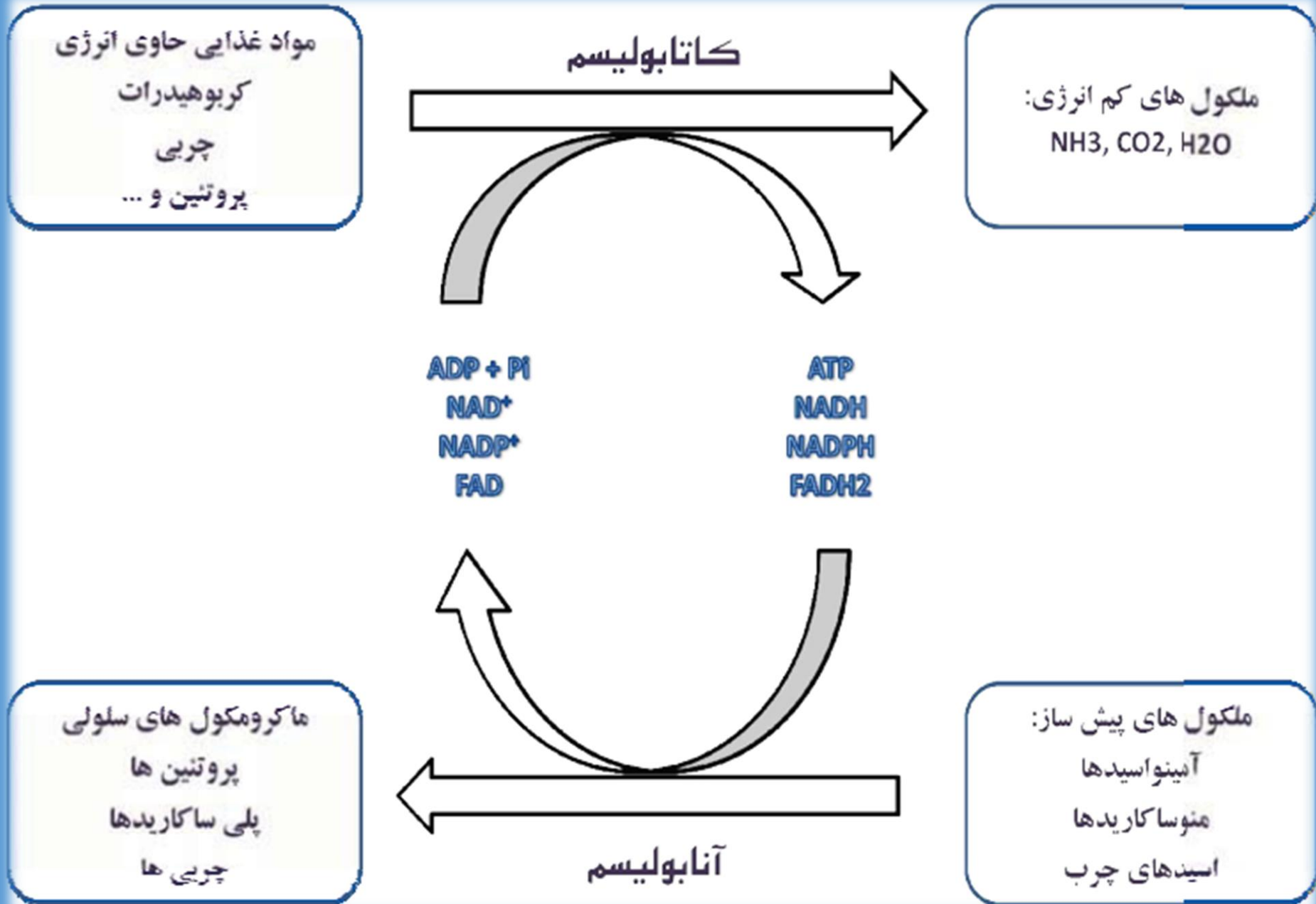


# ✓ اصول متابولیسم و بیوانرژیژتیک:

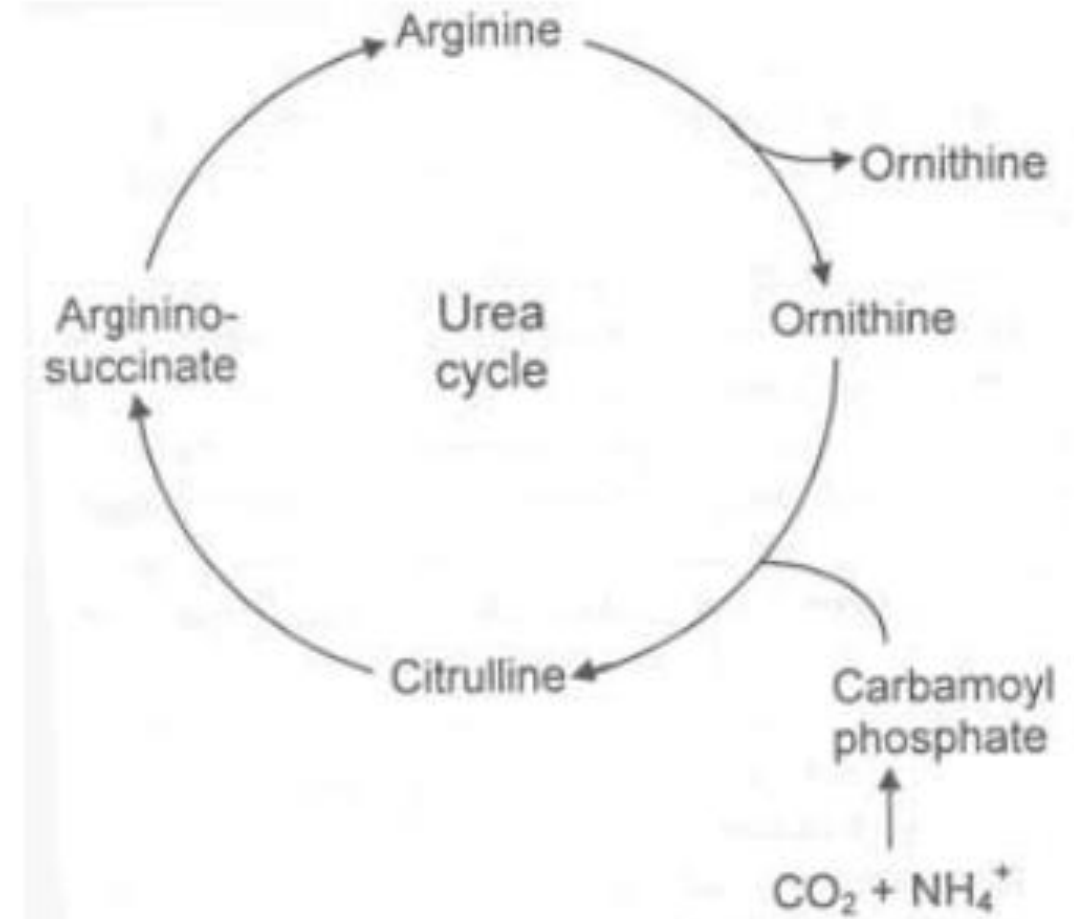
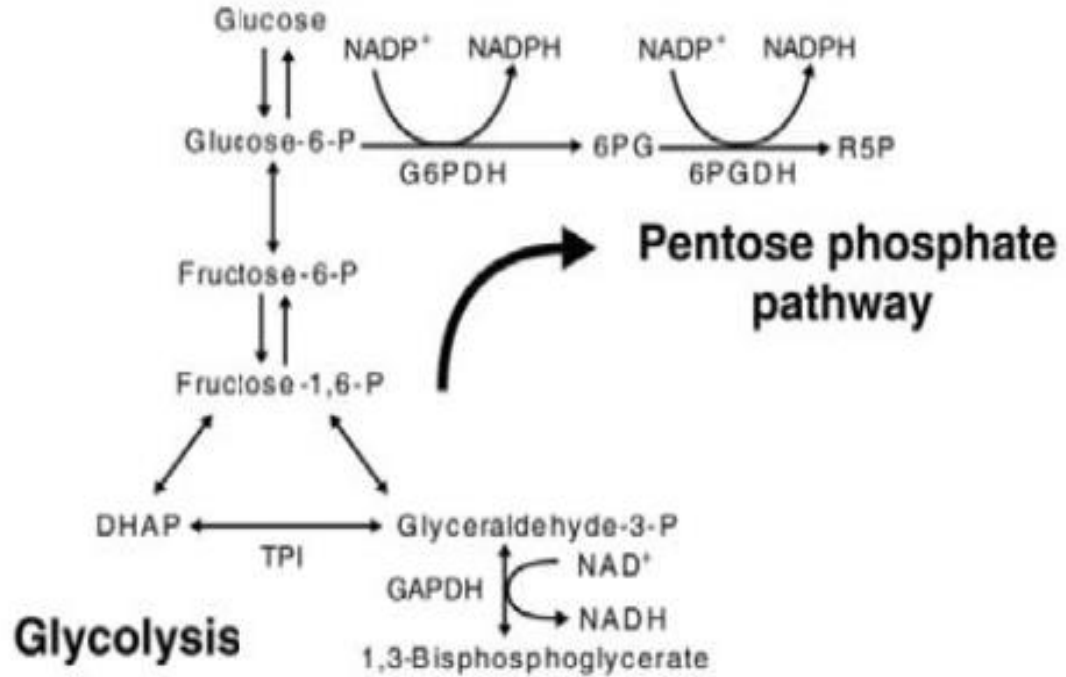


- مقدمه
- تغییر انرژی آزاد
- واکنش‌های جفت شده

# متابولیسم:



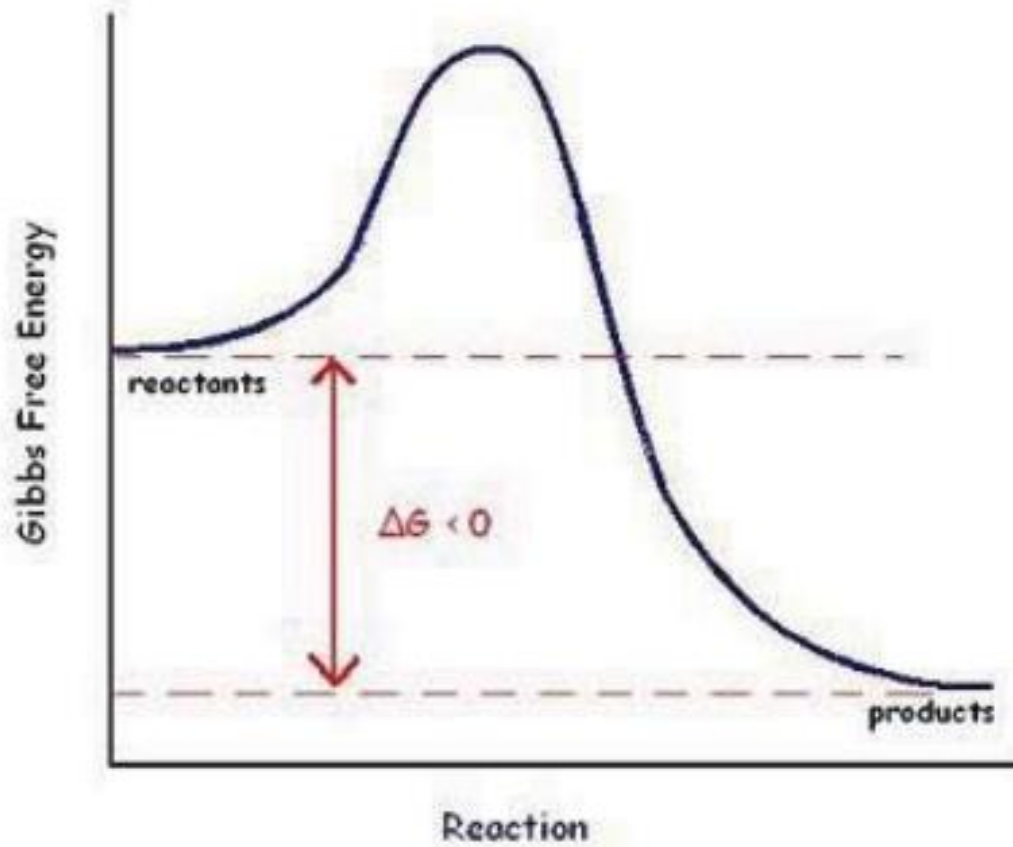
# متابوليسم:



# تغییر انرژی آزاد:

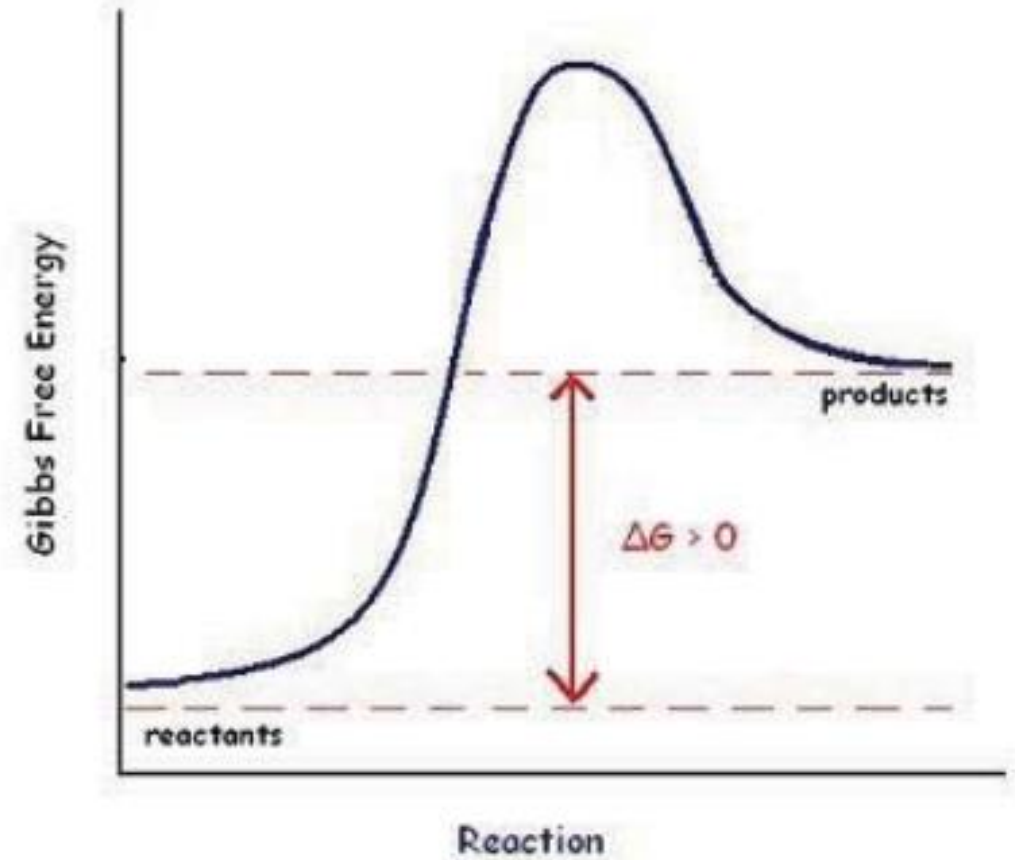
Exergonic Reaction:  $\Delta G < 0$

-Reaction is spontaneous.



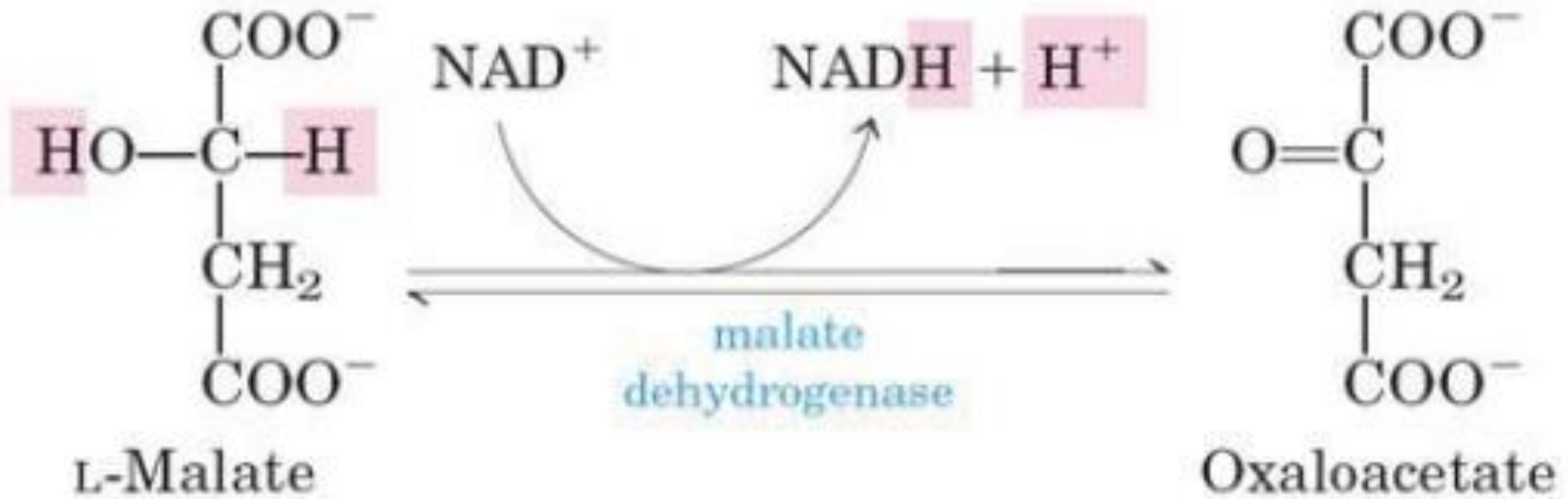
Endergonic Reaction:  $\Delta G > 0$

-Reaction is not spontaneous.





# تغییر انرژی آزاد:

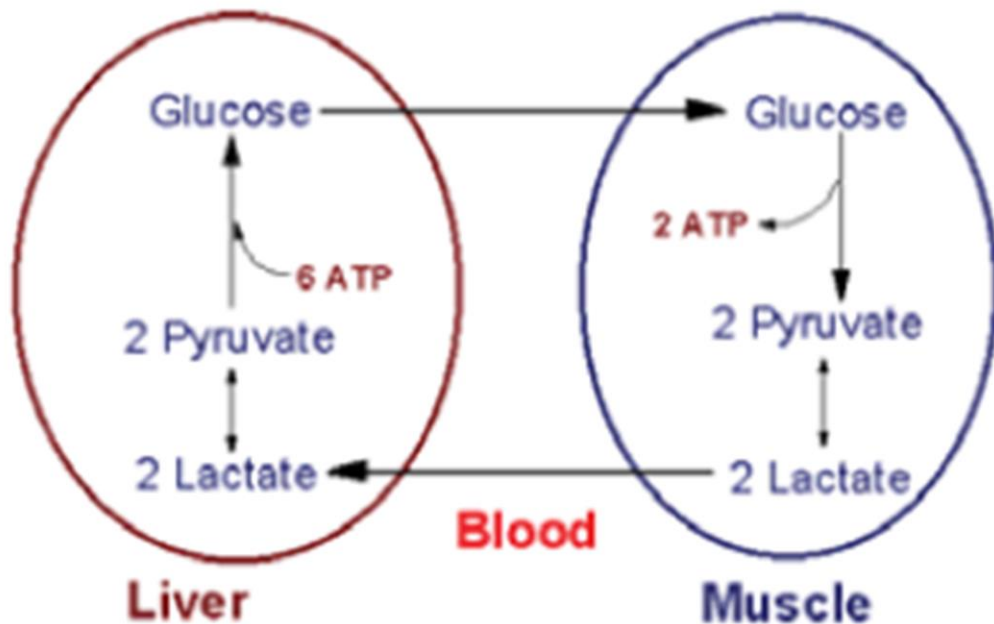


$$\Delta G'^{\circ} = 29.7 \text{ kJ/mol}$$

## قدرت الکترون دهی:

Redox pair	$E^0$ volt
$\text{NAD}^+/\text{NADH}$	-0.32
Pyr/Lac	-0.19
Oxal/Malat	-0.17
$\text{FAD}/\text{FADH}_2$	-0.06
Fumarat/Succinat	+0.13
Oxygen/Water	+0.82

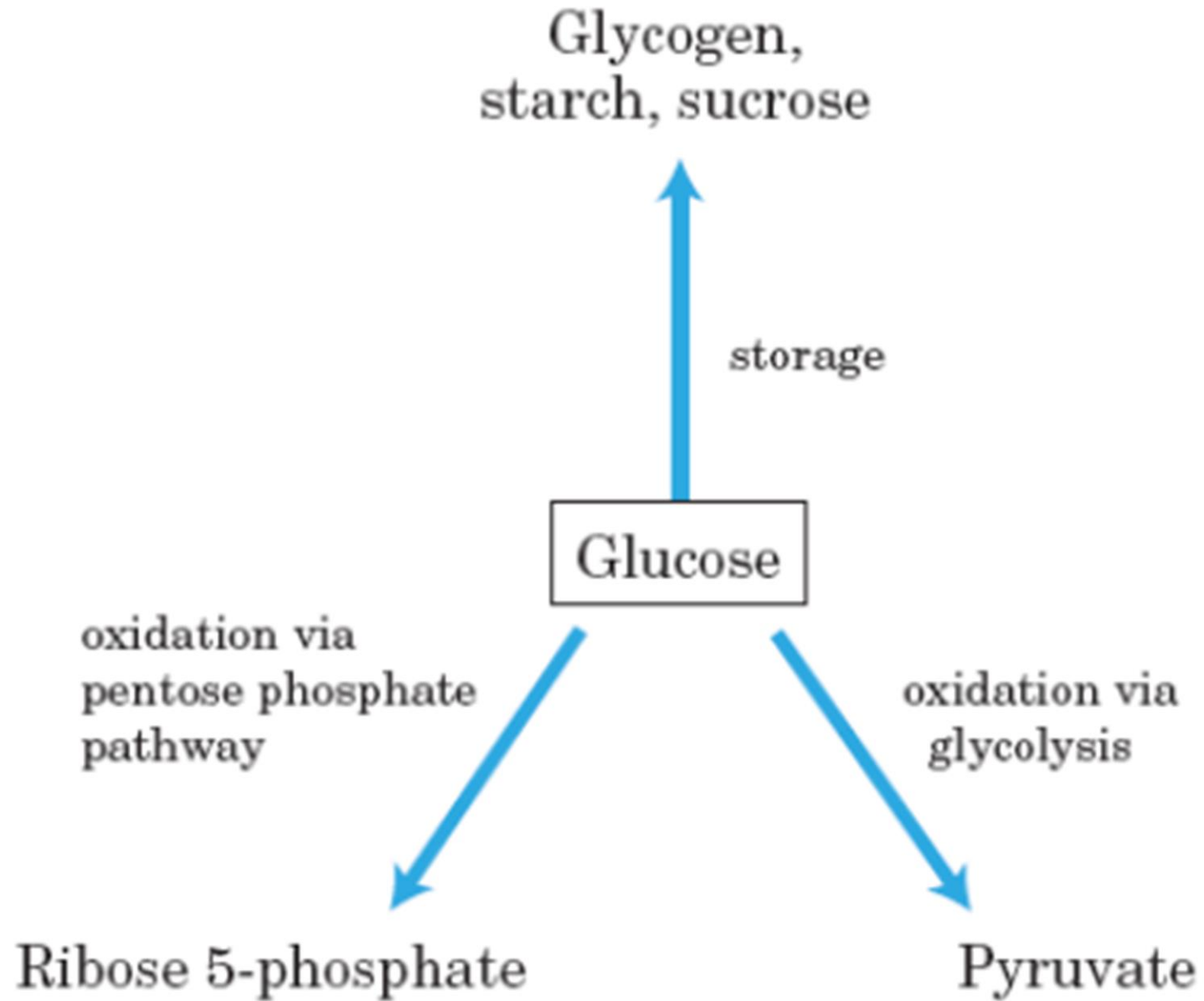
# متابولیسم کربوهیدراتها: ✓



مقدمه

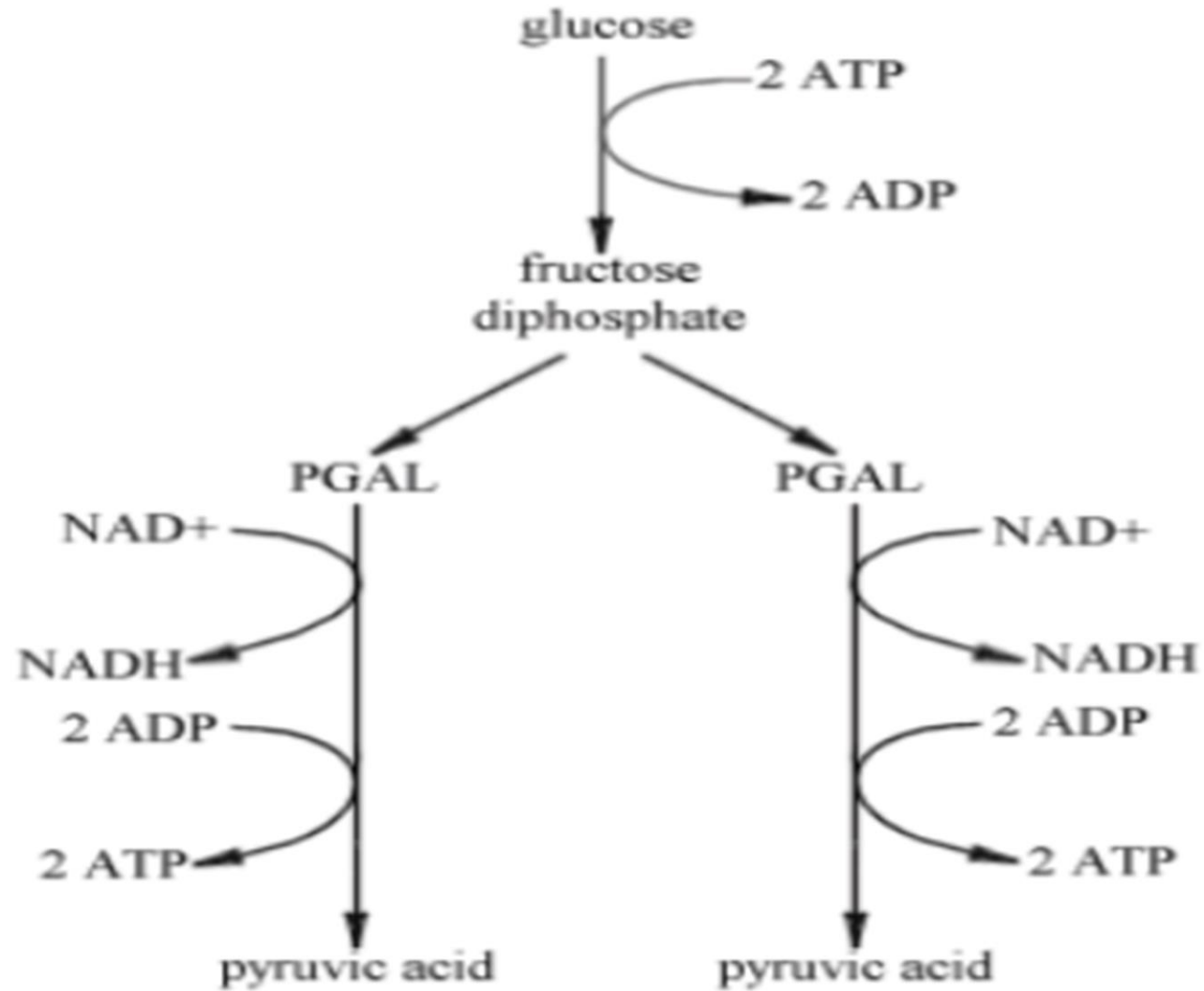
• آنابولیسم کربوهیدراتها  
• کاتابولیسم کربوهیدراتها

# مسیرهای اصلی استفاده از گلوکز:

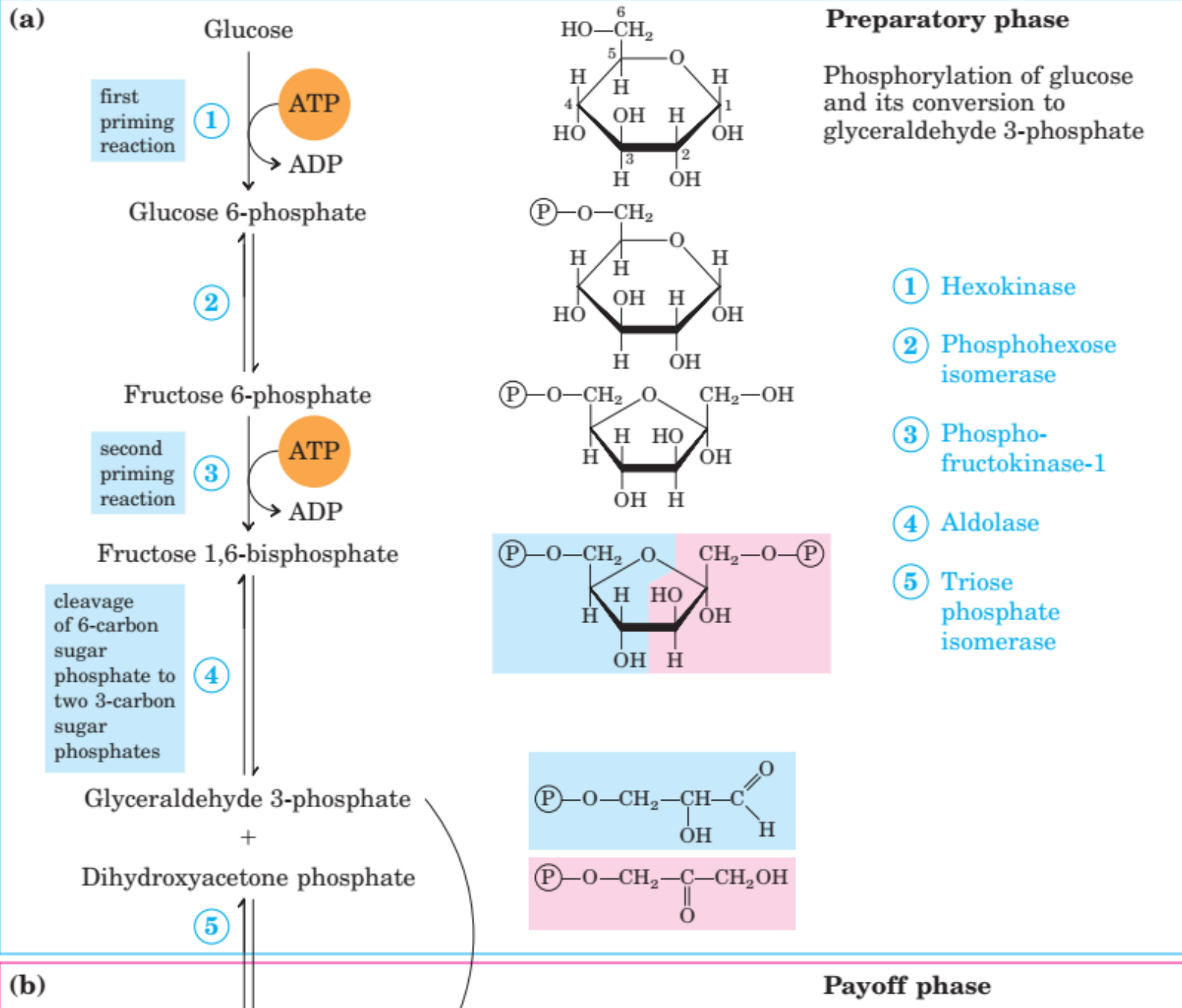


# گلیکولیز:

## Glycolysis

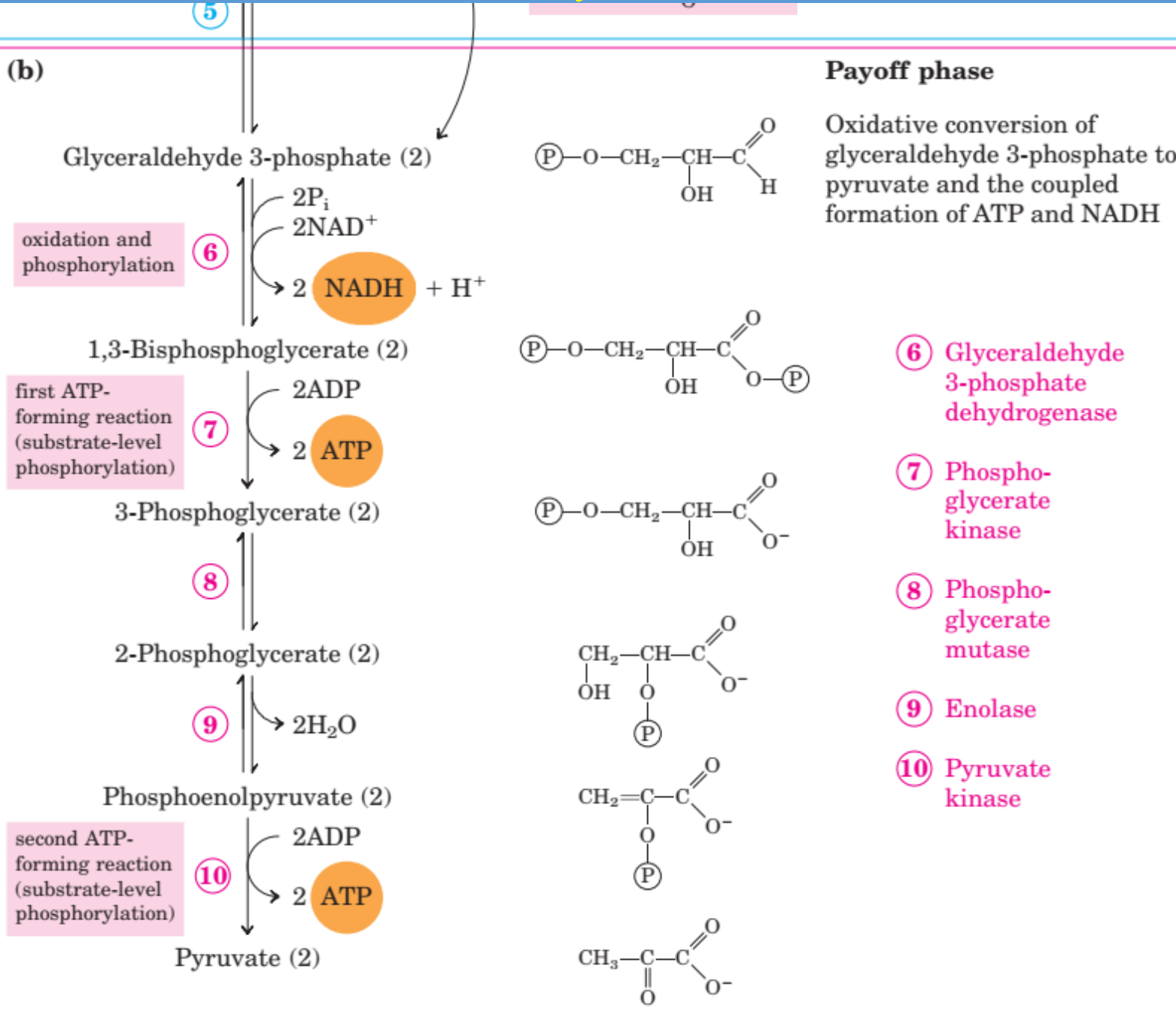


# گلیکولیز:

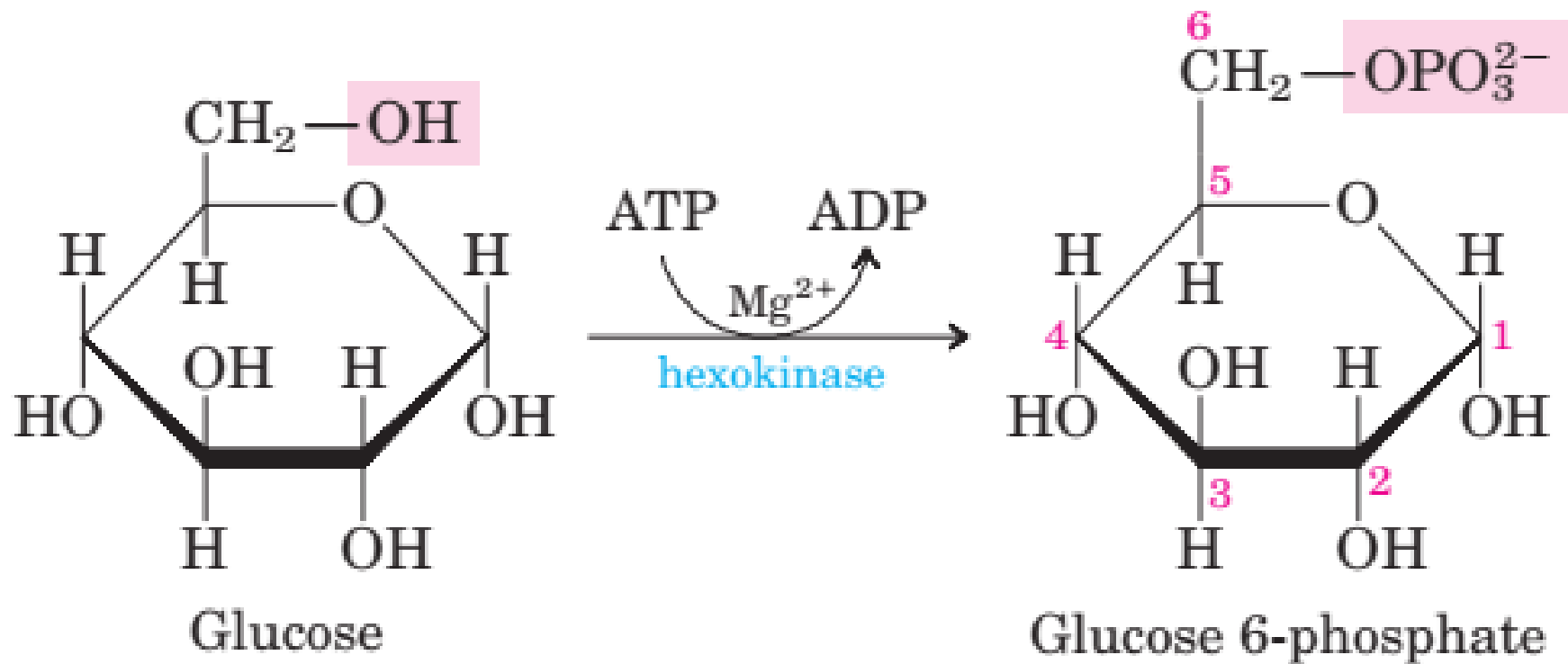




# گلیکولیز:

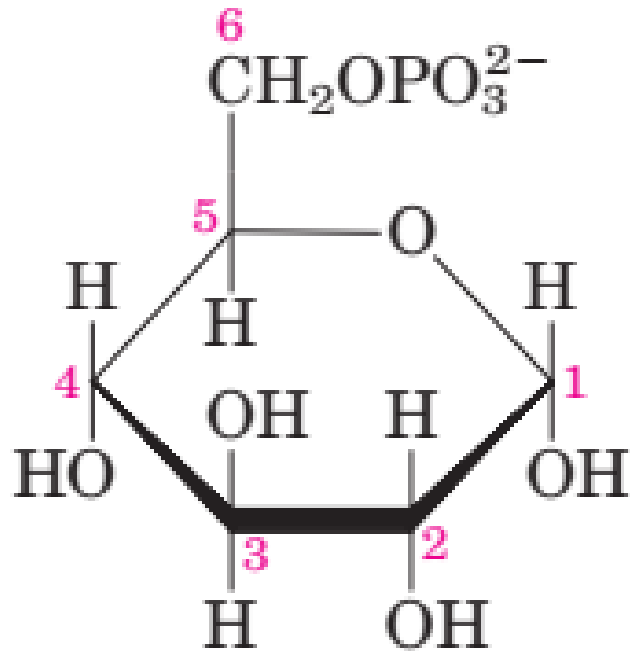


گلیکولیز:  
فاز آماده‌سازی:  
مرحله ۱:

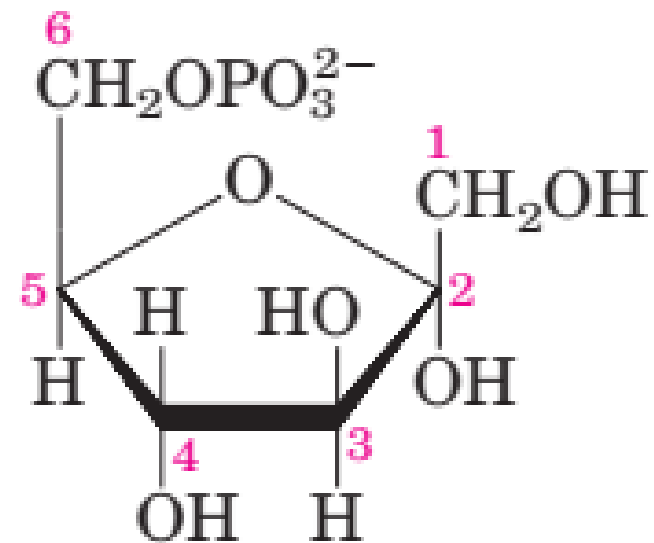
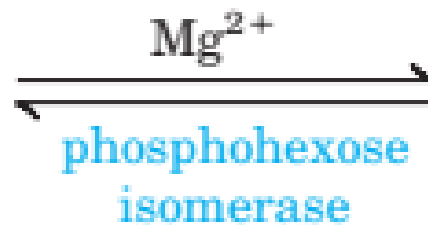


$$\Delta G'^{\circ} = -16.7 \text{ kJ/mol}$$

گلیکولیز:  
فاز آماده‌سازی:  
مرحله ۲:



Glucose 6-phosphate



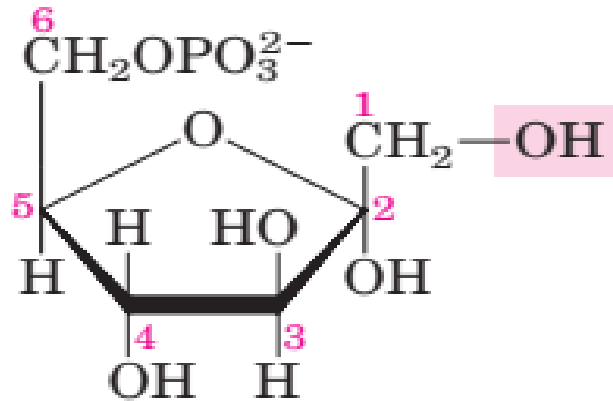
Fructose 6-phosphate

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

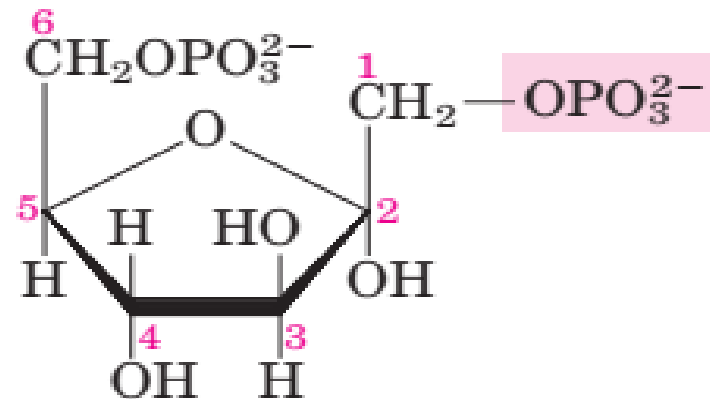
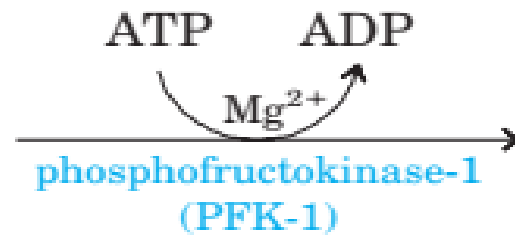
# گلیکولیز:

فاز آماده‌سازی:

مرحله ۳:



Fructose 6-phosphate



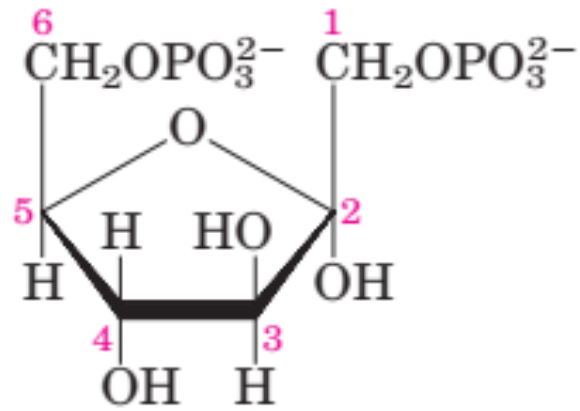
Fructose 1,6-bisphosphate

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

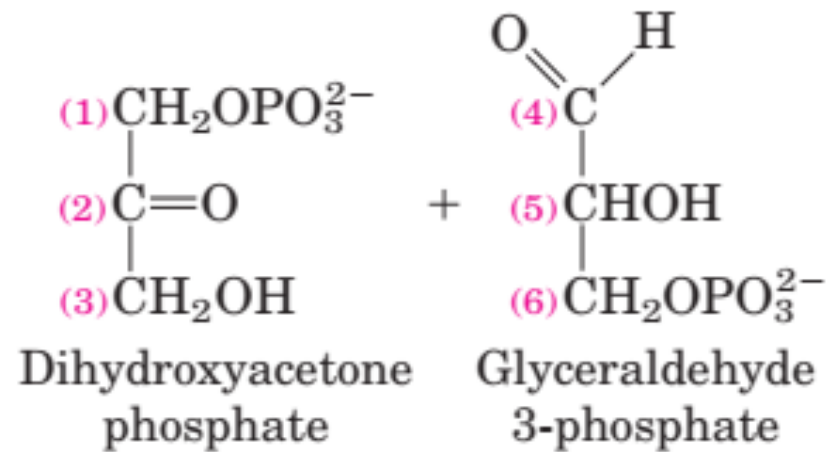
# گلیکولیز:

## فاز آماده سازی:

### مرحله ۴:

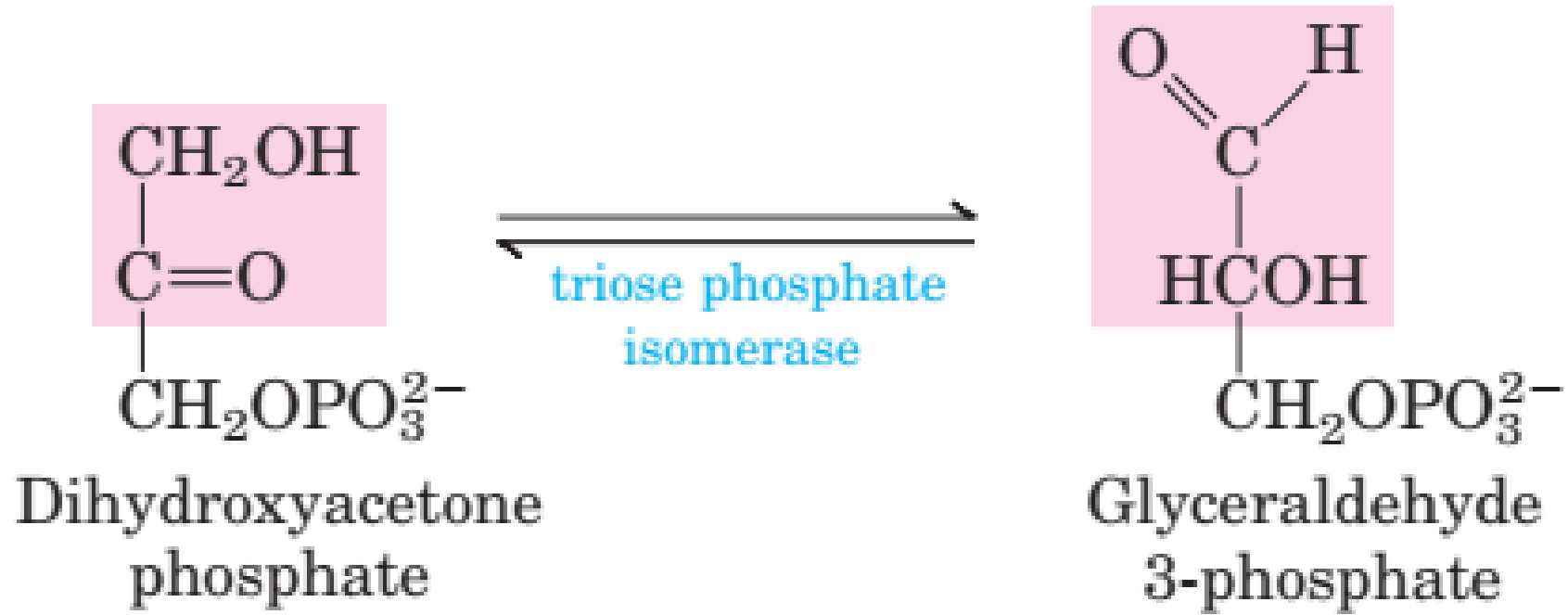


Fructose 1,6-bisphosphate



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

گلیکولیز:  
فاز آماده‌سازی:  
مرحله ۵:



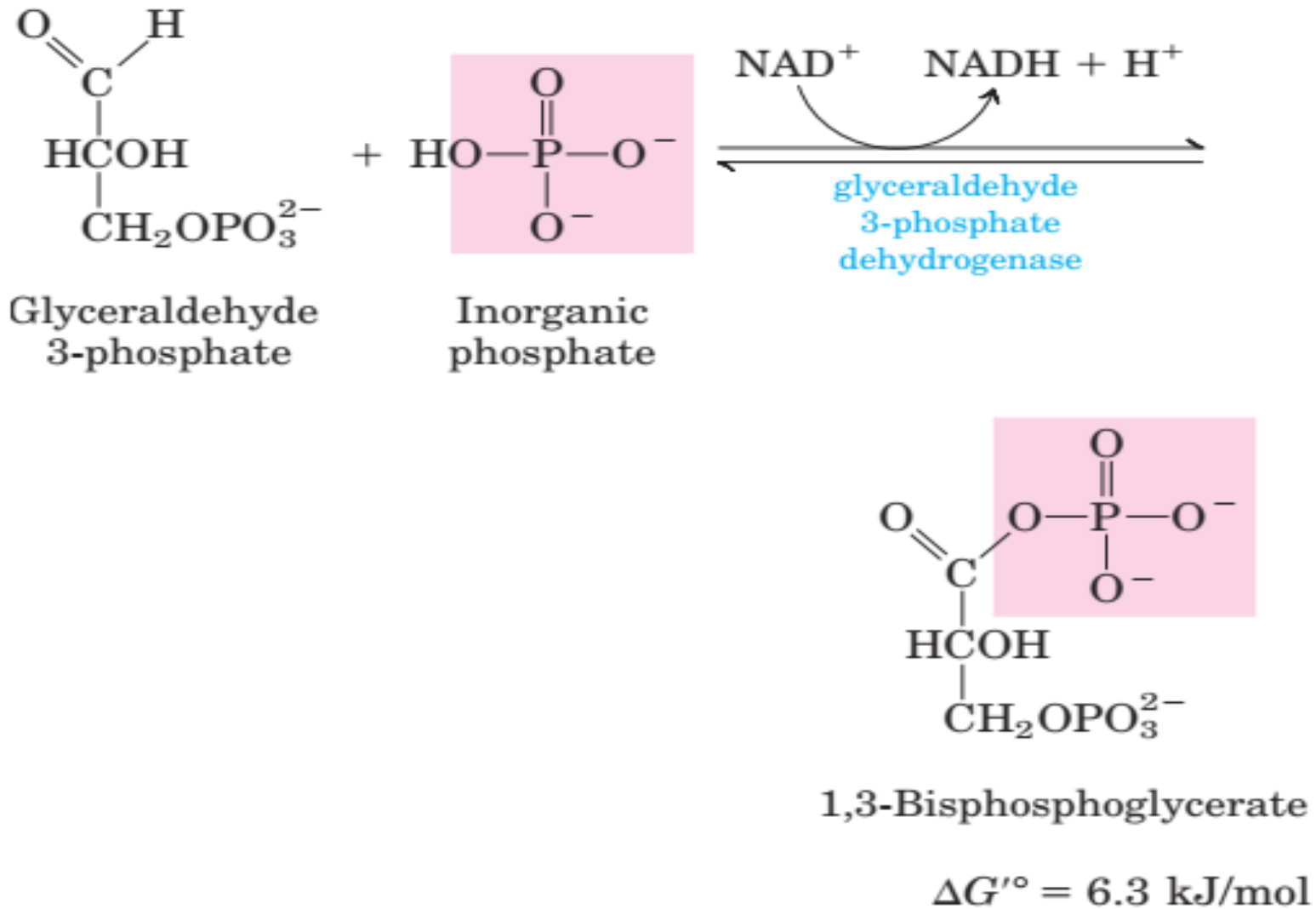
$\Delta G'^{\circ} = 7.5 \text{ kJ/mol}$



# گلیکولیز:

فاز بہرہوری:

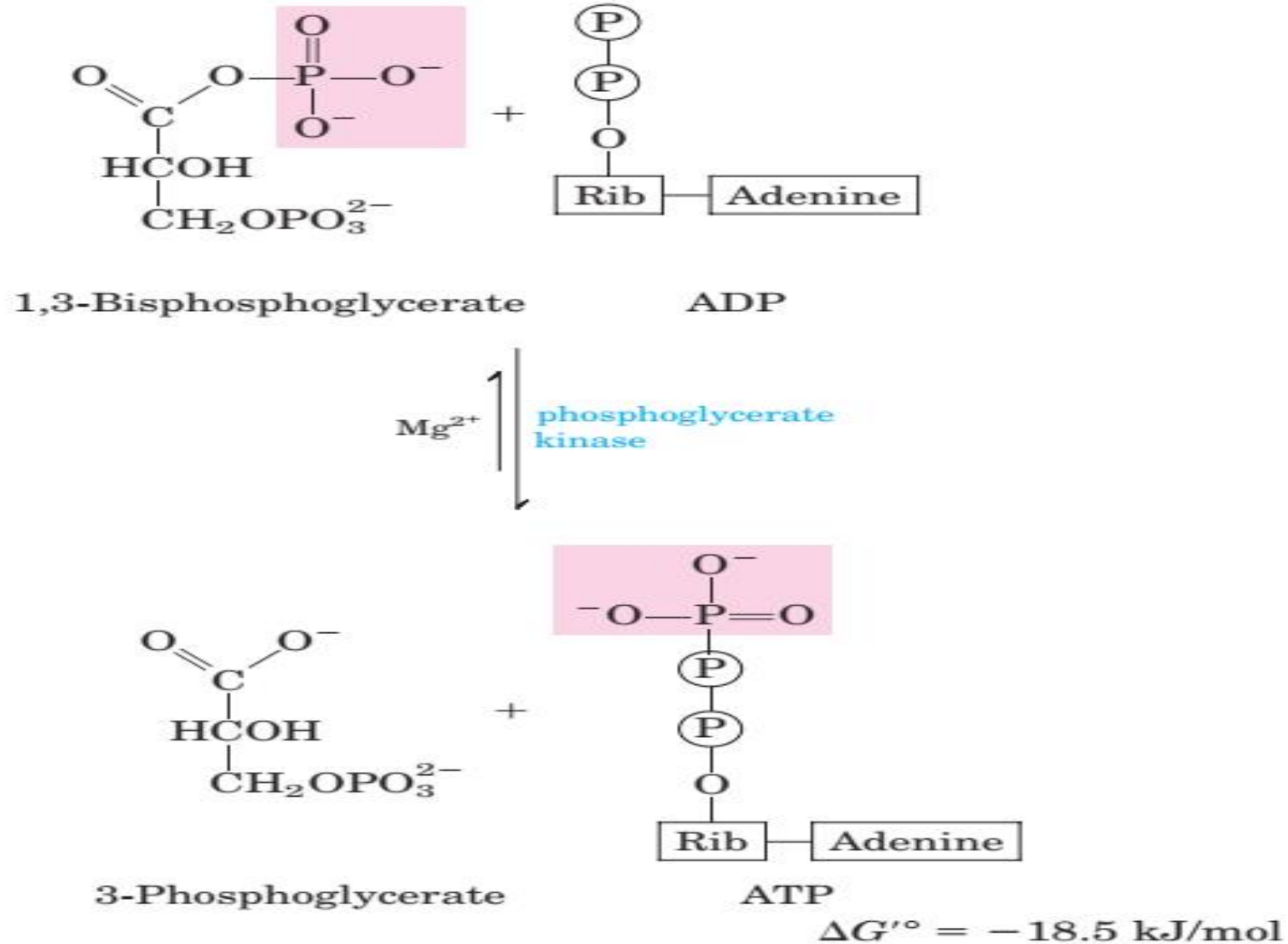
مرحلہ ۶:



# گلیکولیز:

فاز بہرہوری:

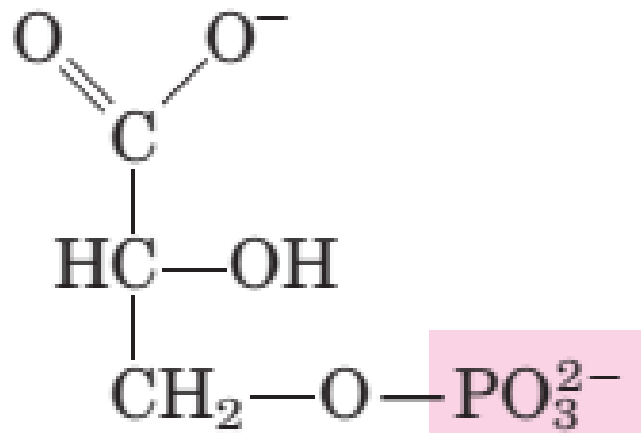
مرحلہ ۷:



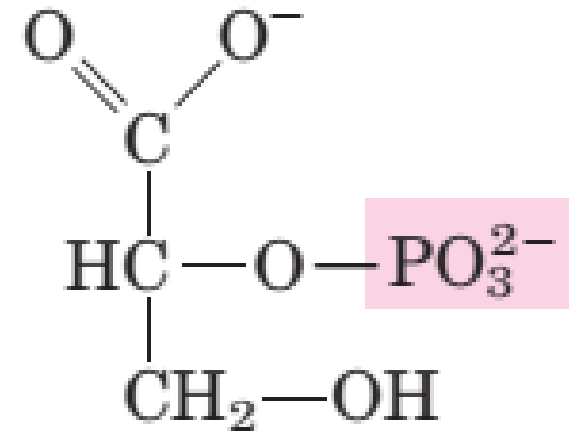
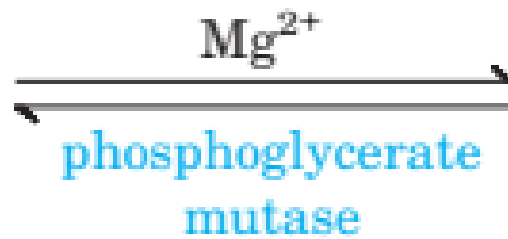
# گلیکولیز:

فاز بهره‌وری:

مرحله ۸:



3-Phosphoglycerate



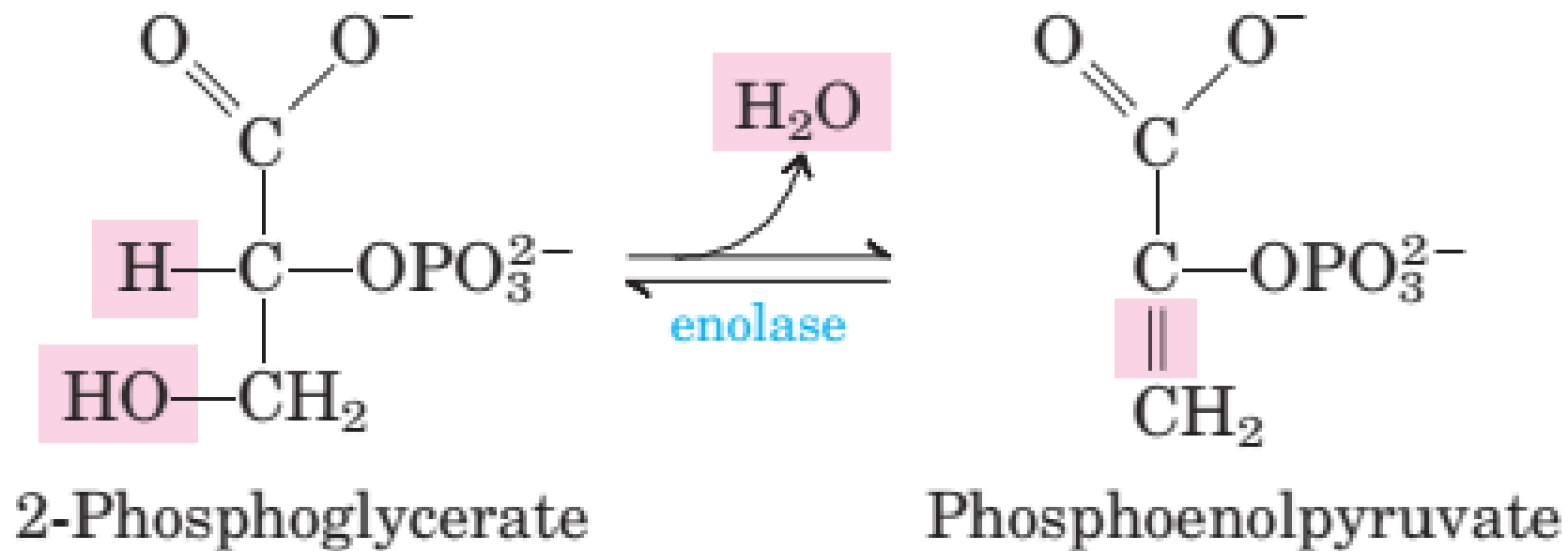
2-Phosphoglycerate

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

# گلیکولیز:

فاز بهره‌وری:

مرحله ۹:

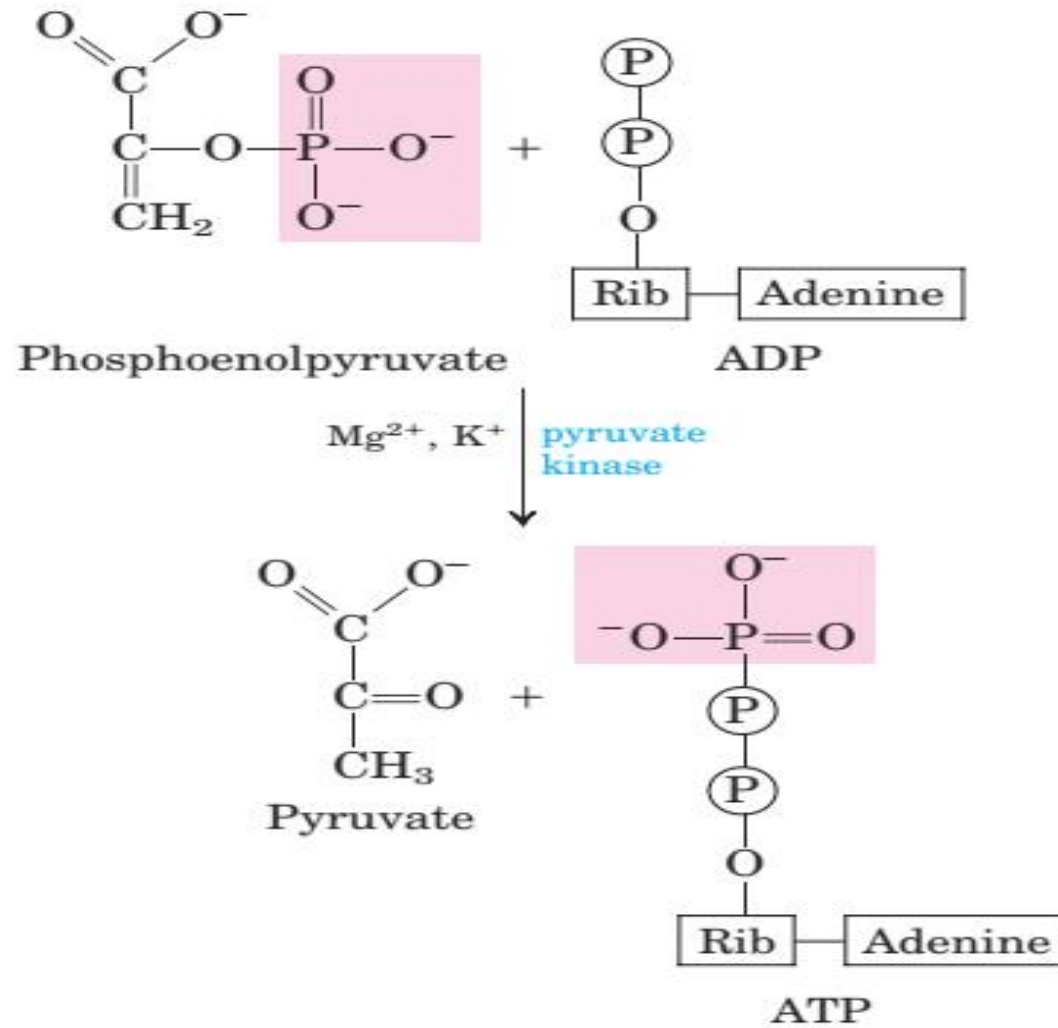


$$\Delta G'^{\circ} = 7.5 \text{ kJ/mol}$$

# گلیکولیز:

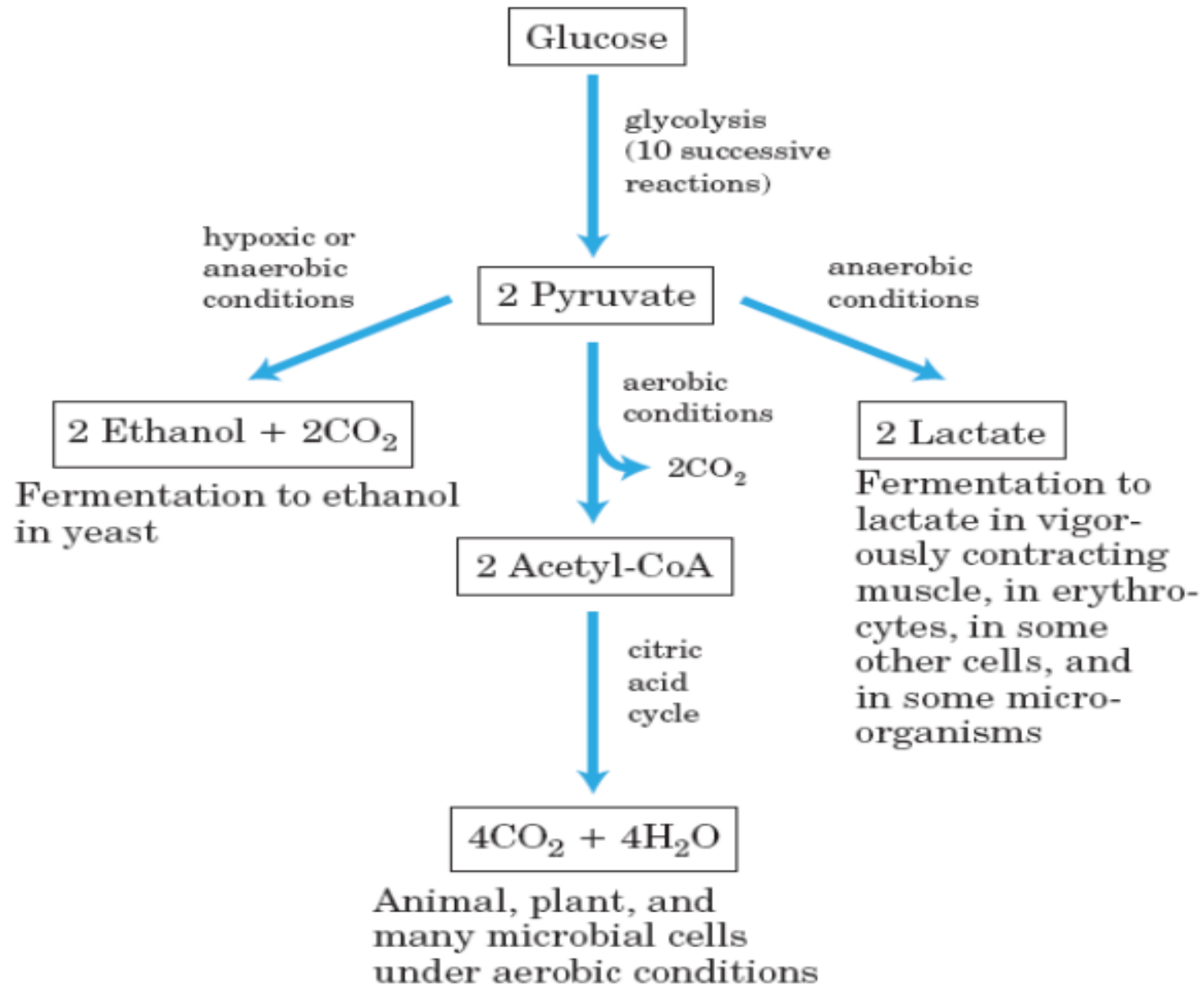
فاز بهره‌وری:

مرحله ۱۰:

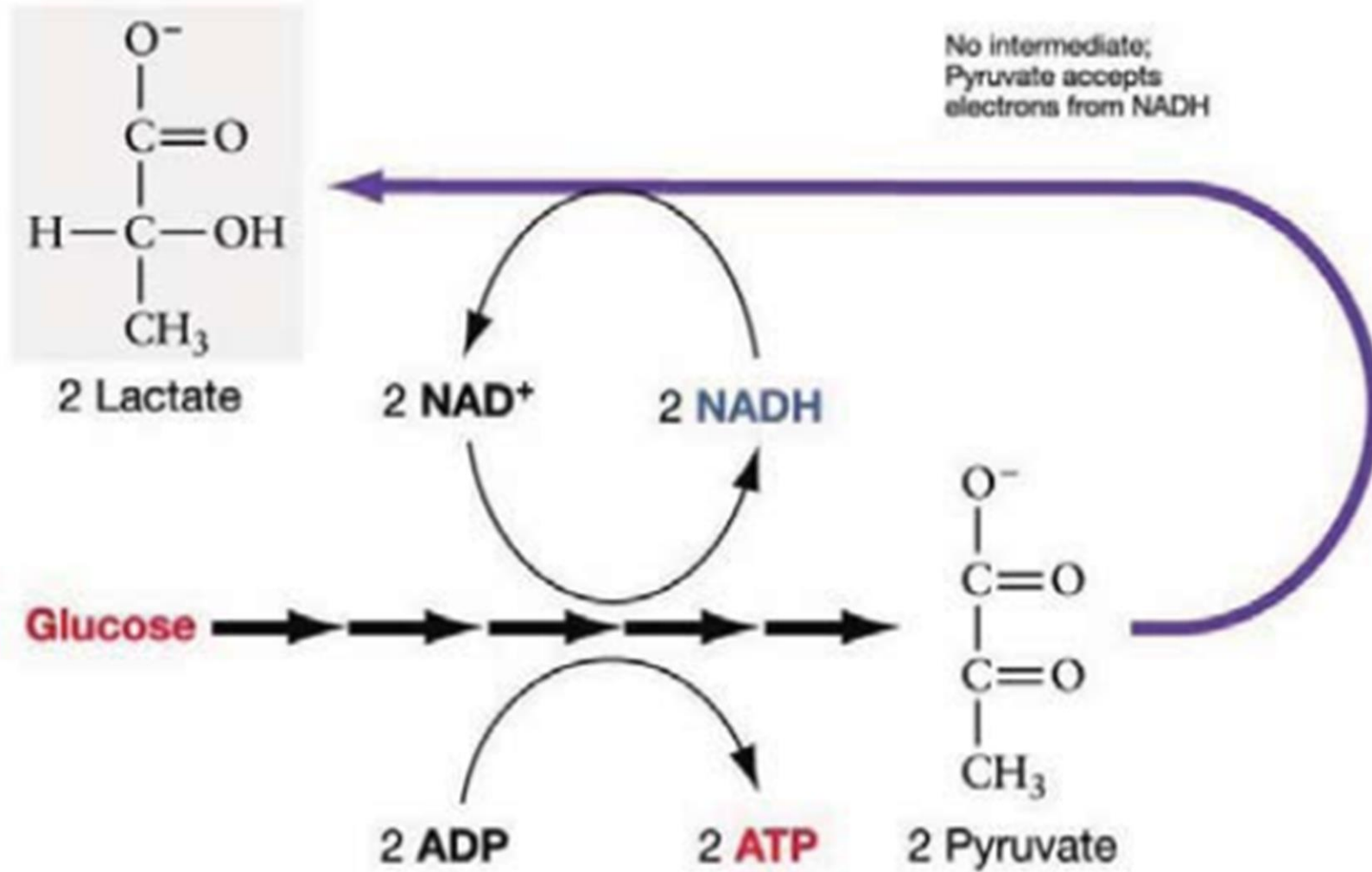


$$\Delta G'^{\circ} = -31.4 \text{ kJ/mol}$$

# سرنوشت پیرووات:



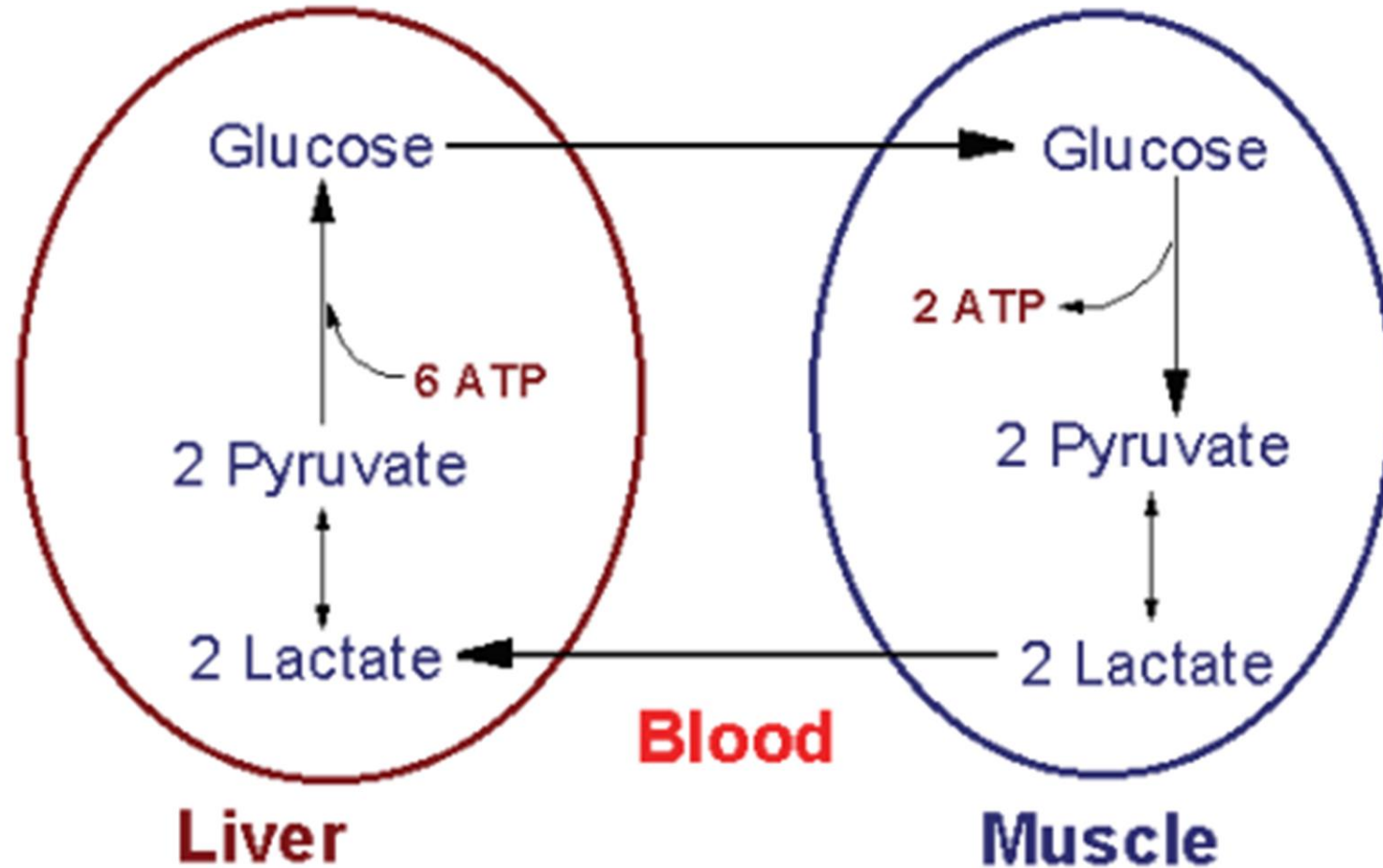
# تخمیر اسید لاکتیکی:



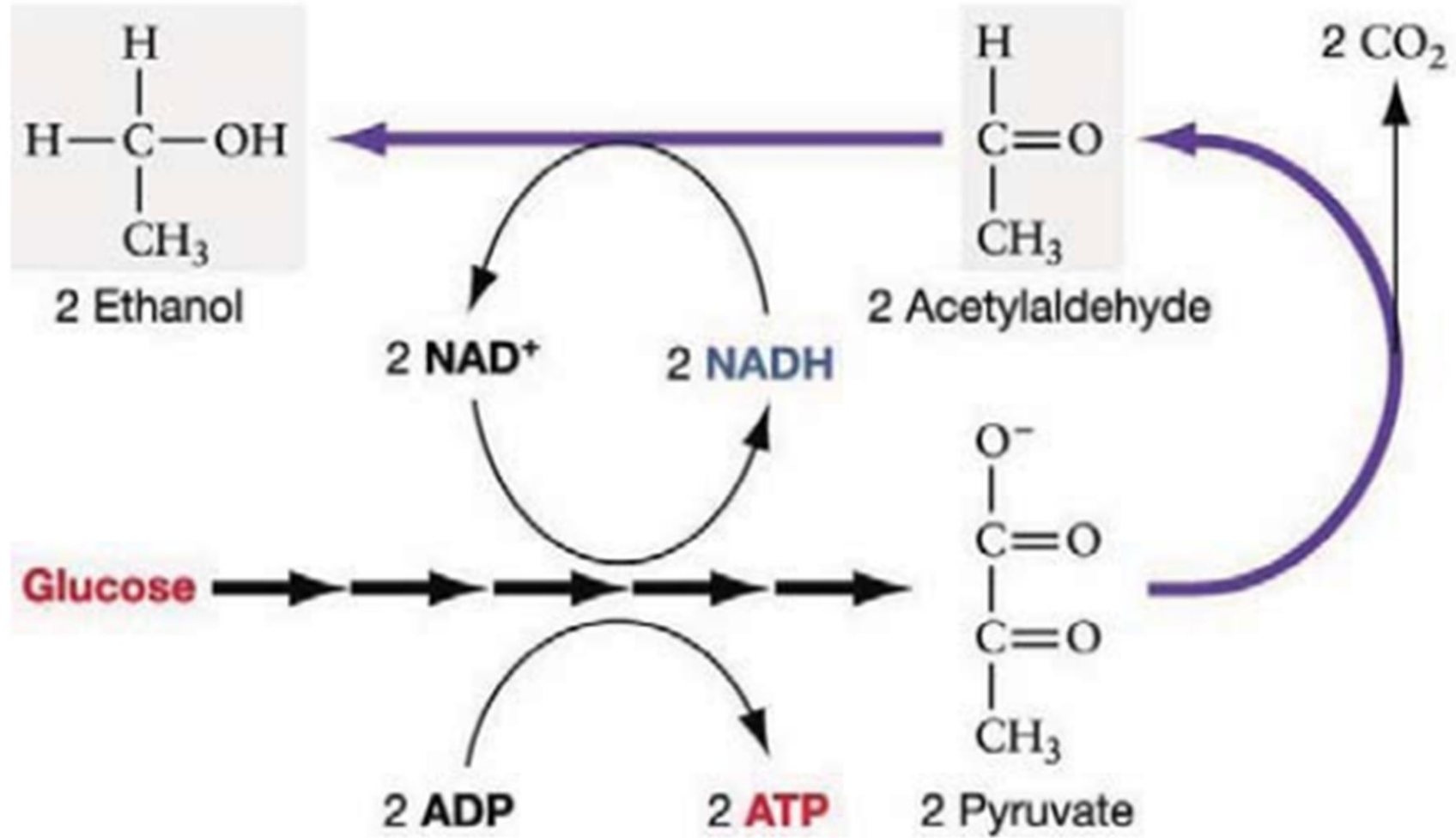


# چرخه کوری:

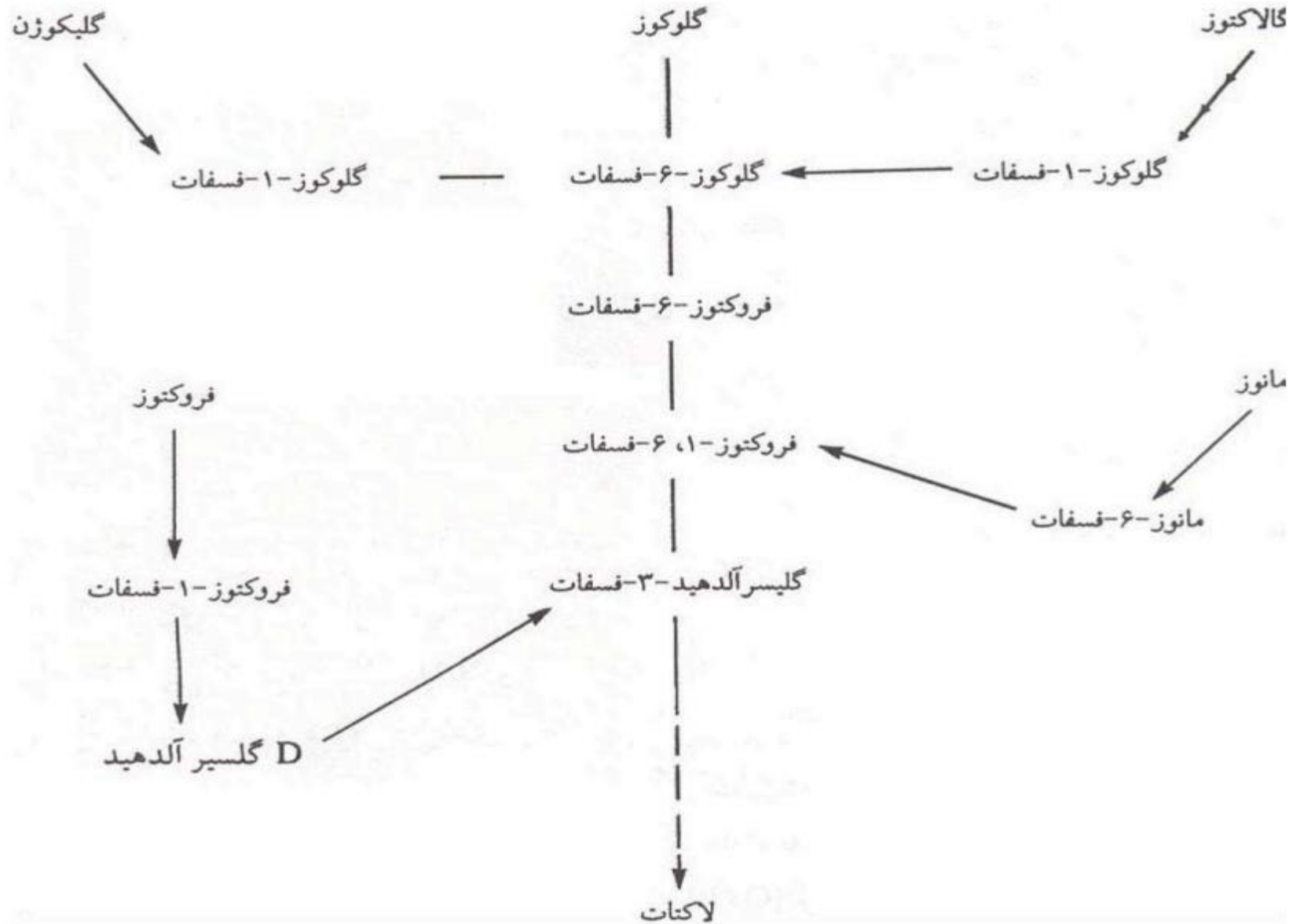
## The Cori Cycle



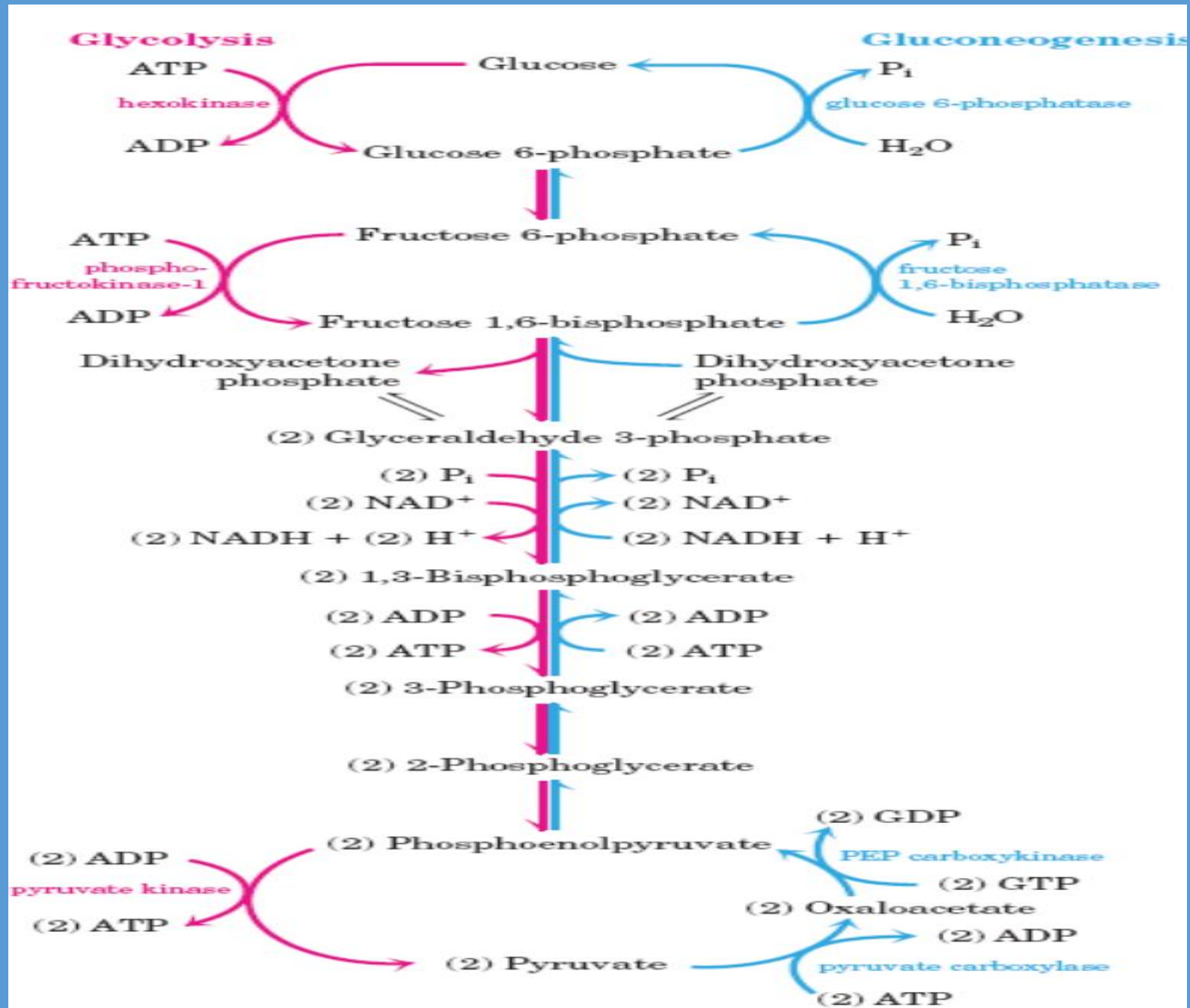
# تخمير الكلى:



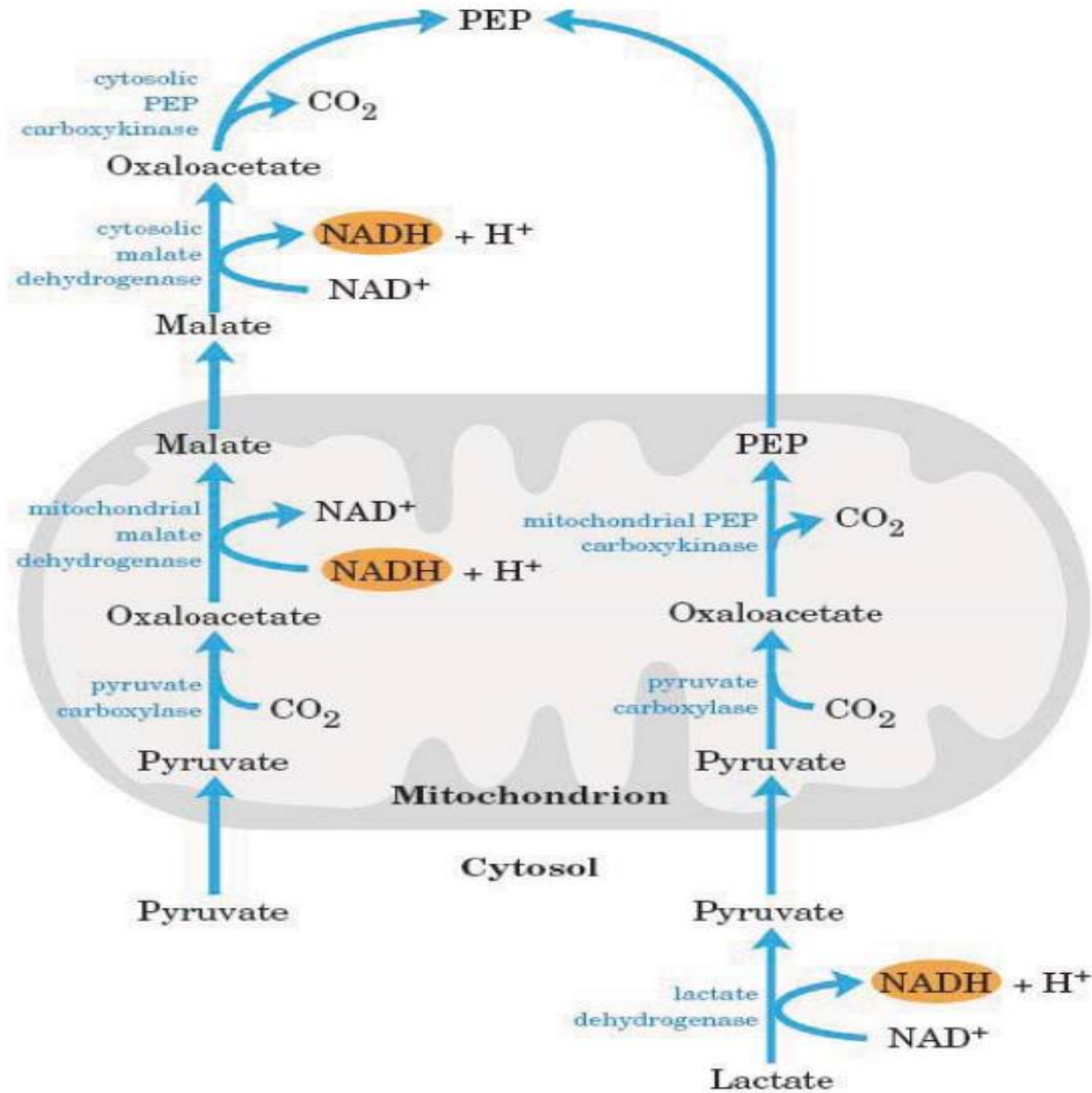
# ورود سایر قندها به مسیر گلیکولیز:



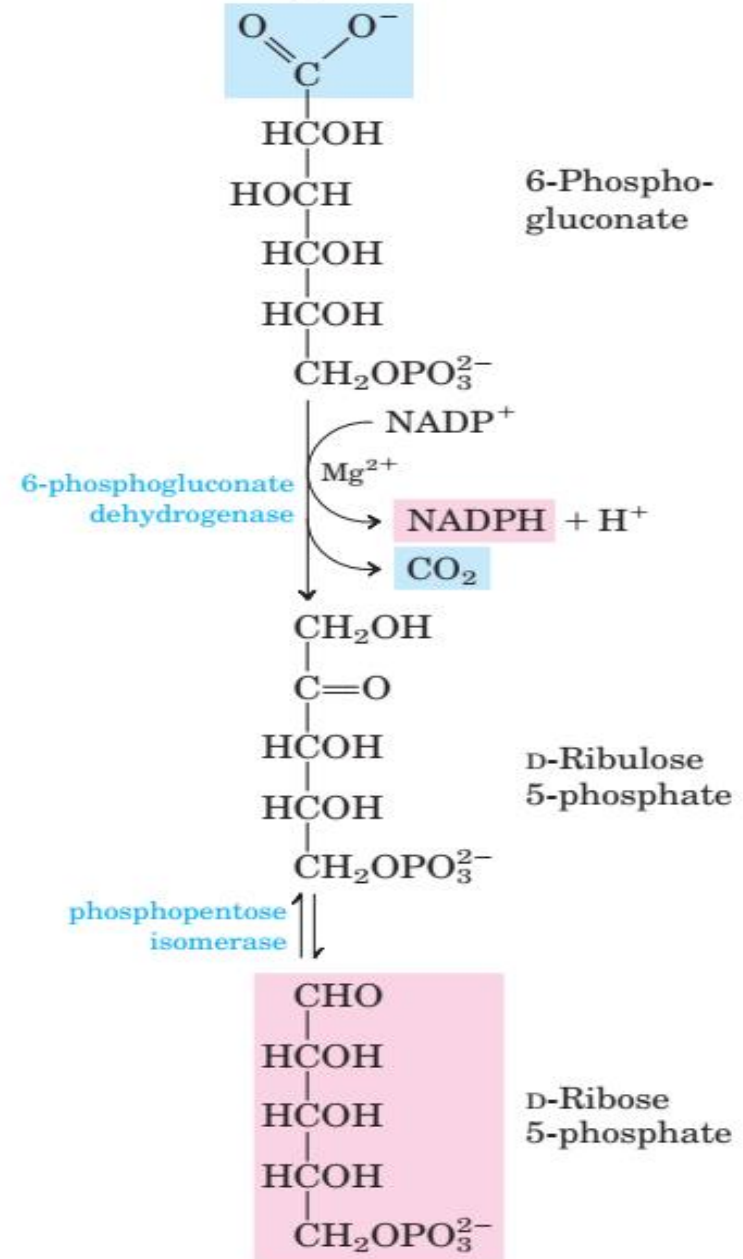
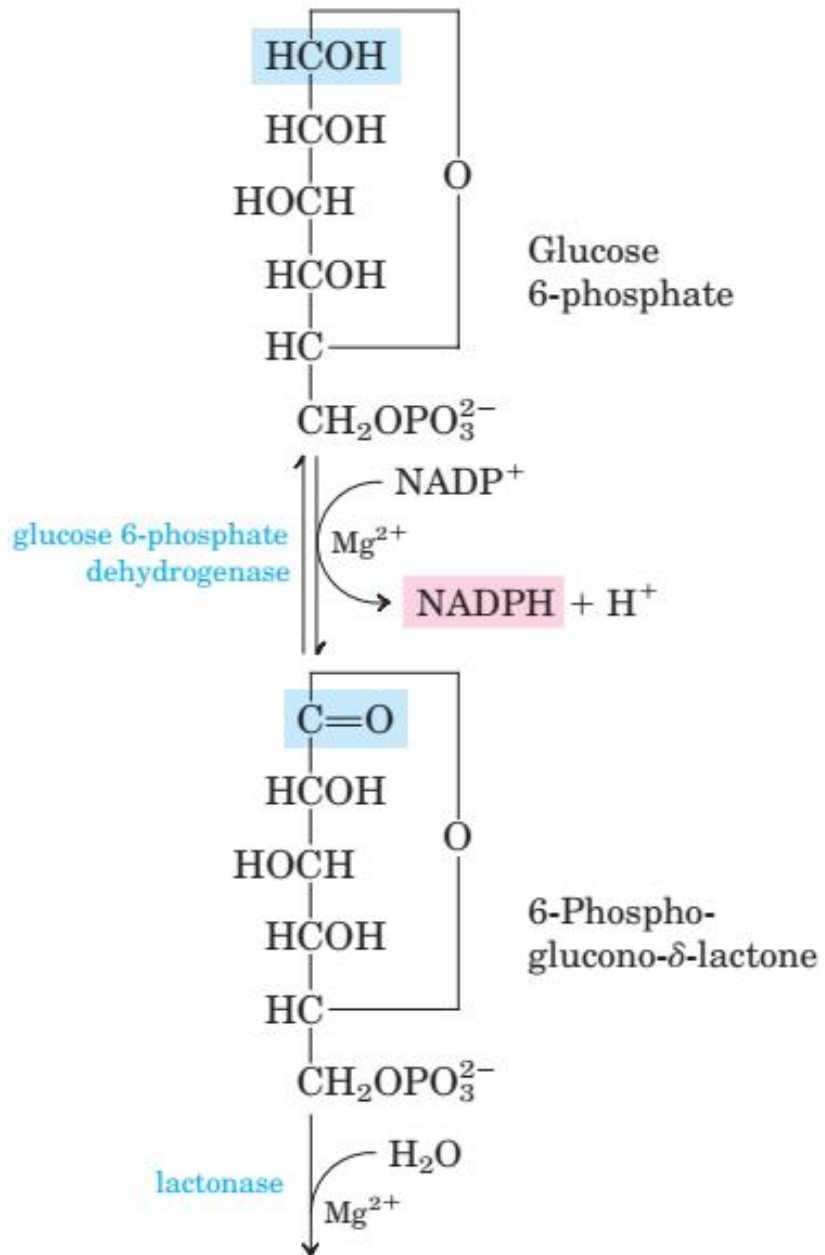
# گلیکونٹوژنز :



# مسیر اول و دوم تبدیل پیرووات به فسفوانول پیرووات :

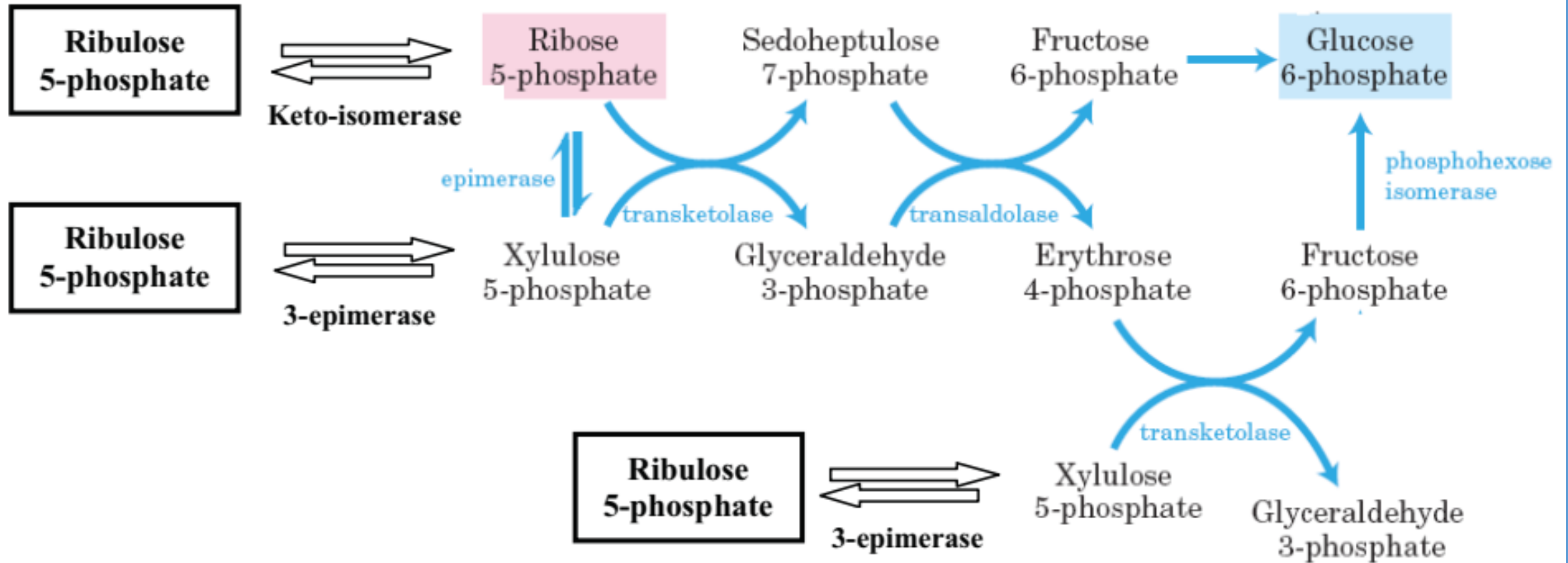


# مرحله اکسیداتیو مسیر پنتوز فسفات:





# مرحله غیراکسیداتیو مسیر پنتوز فسفات:

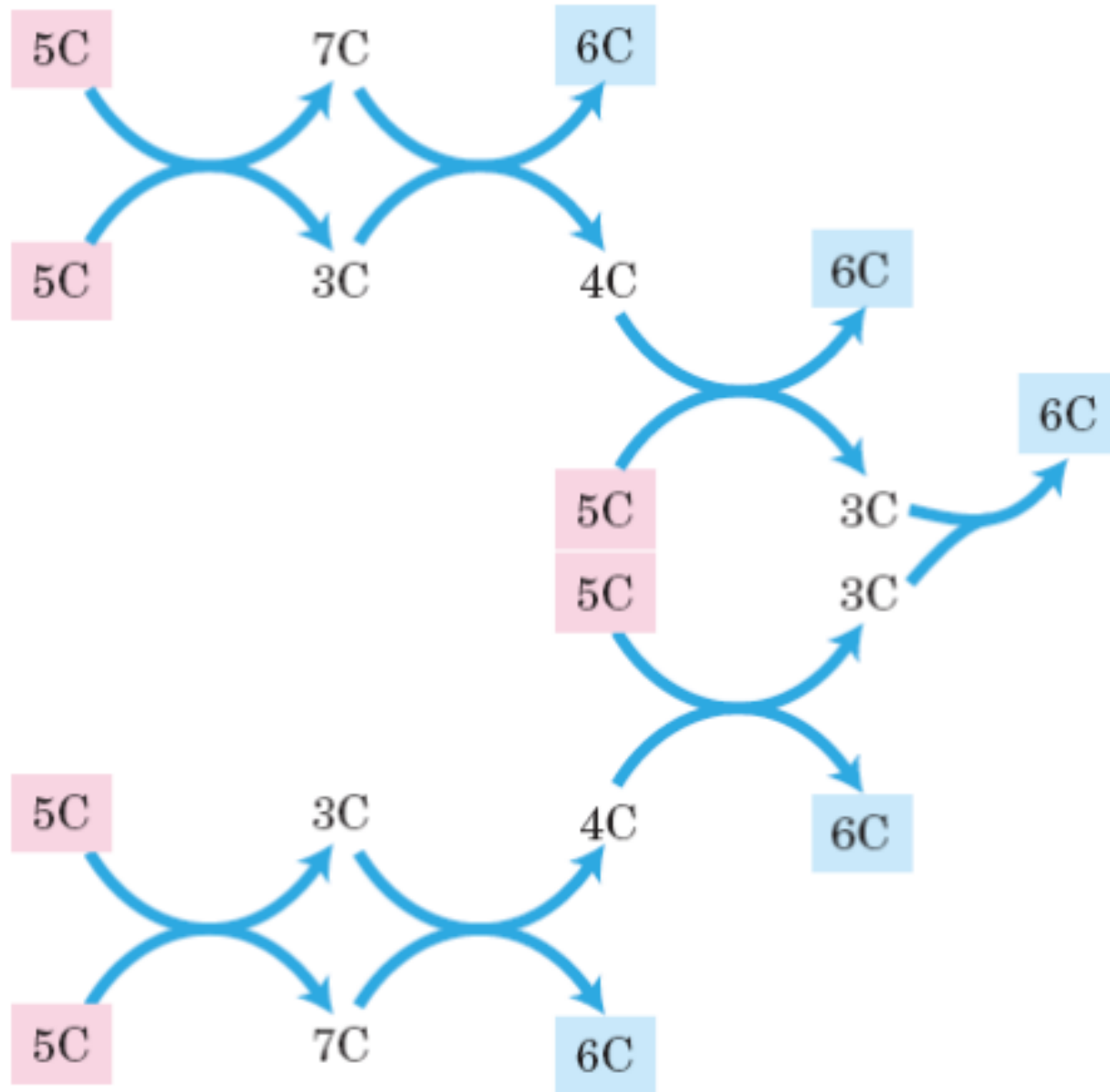


(a)

**FIGURE 14-22** Nonoxidative reactions of the pentose phosphate pathway.



# روند کلی تبدیل شش پنتوز به پنج هگوز:

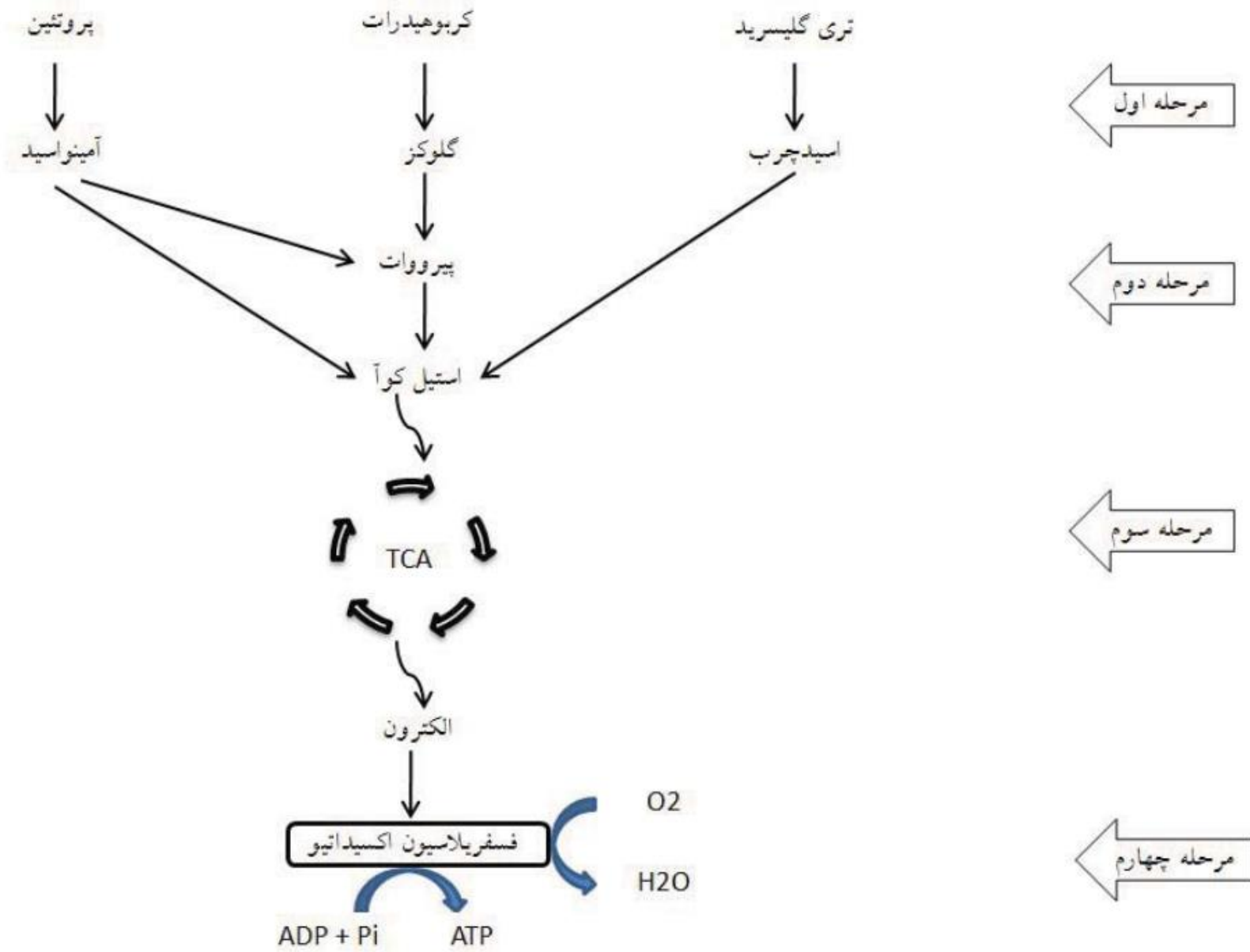


# ✓ اکسیداسیون هوازی:

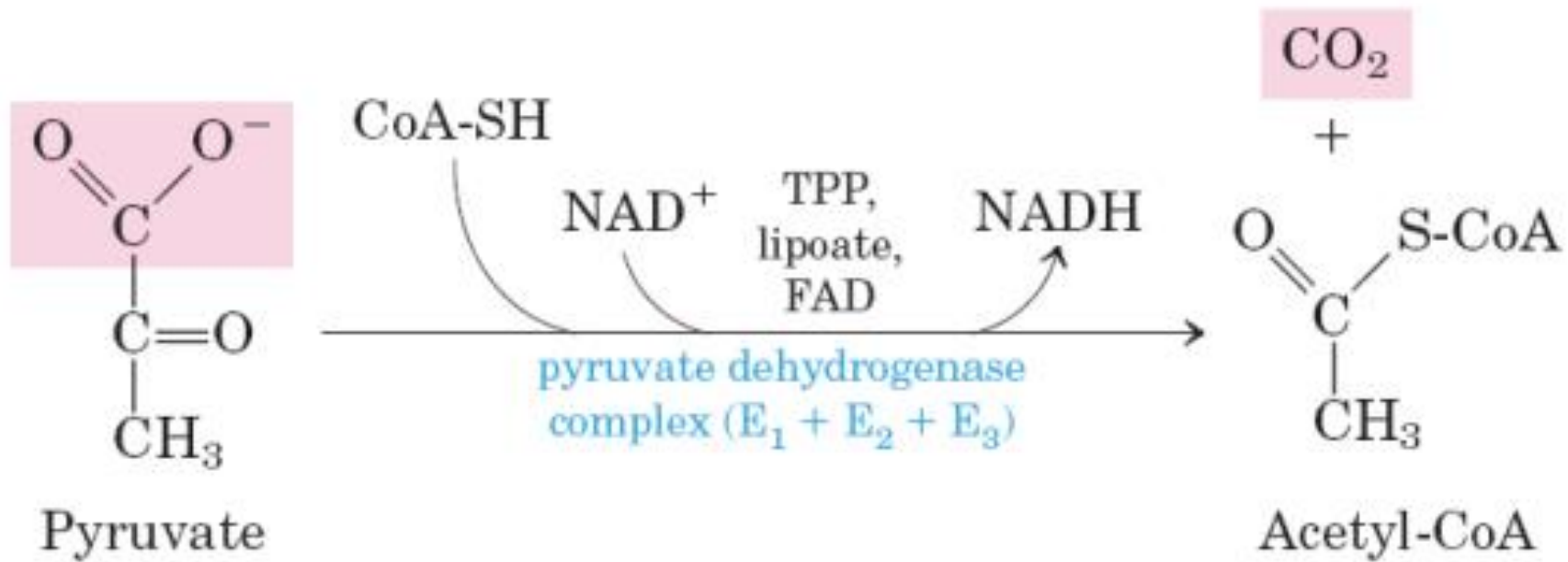


- مقدمه
- چرخه اسید سیتریک (کربس)
- فسفریلاسیون اکسیداتیو

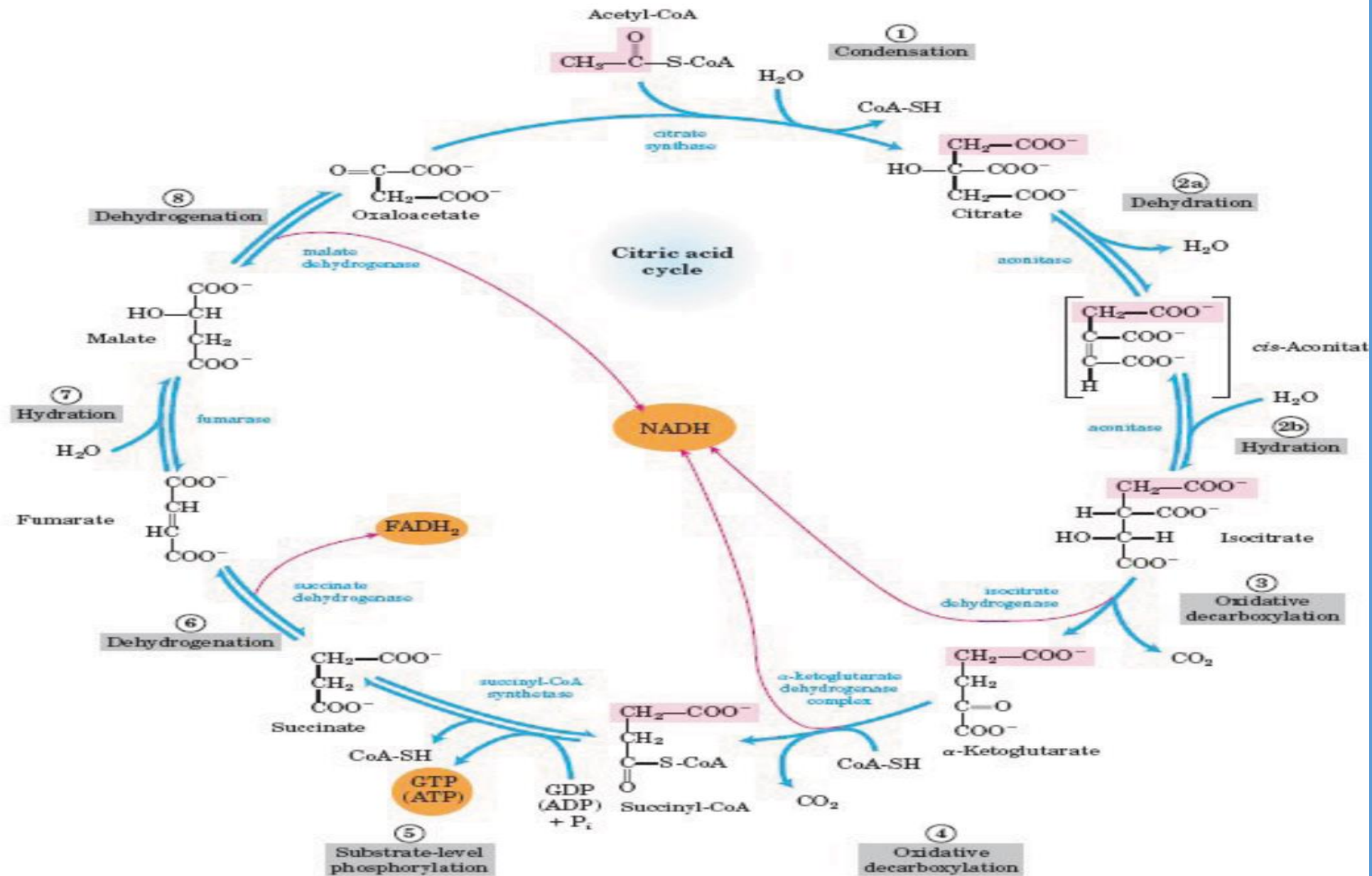
# اکسیداسیون هوازی در نگاه کلی:



# تبدیل پیرووات به استیل کوآ:

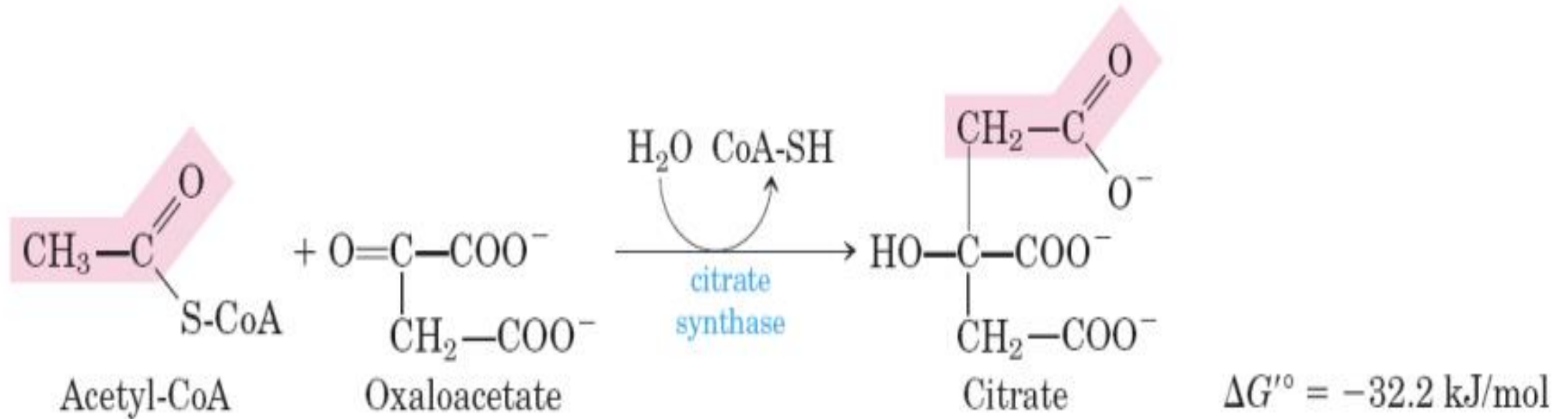


# چرخه اسید سیتریک (TCA):



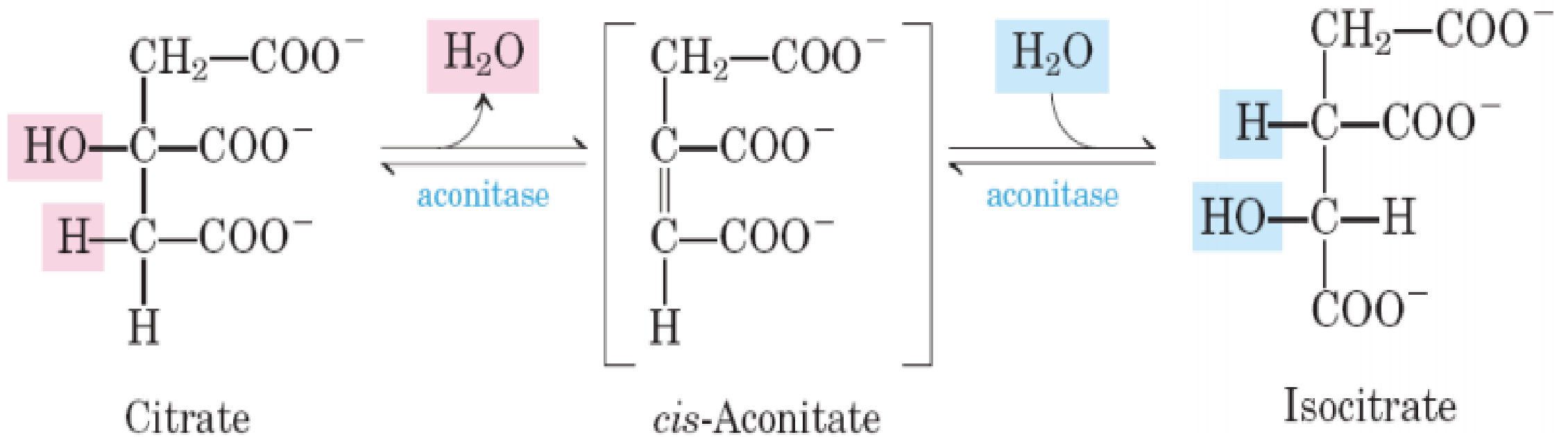
# چرخه اسید سیتریک

## مرحله ۱:



# چرخه اسید سیتریک

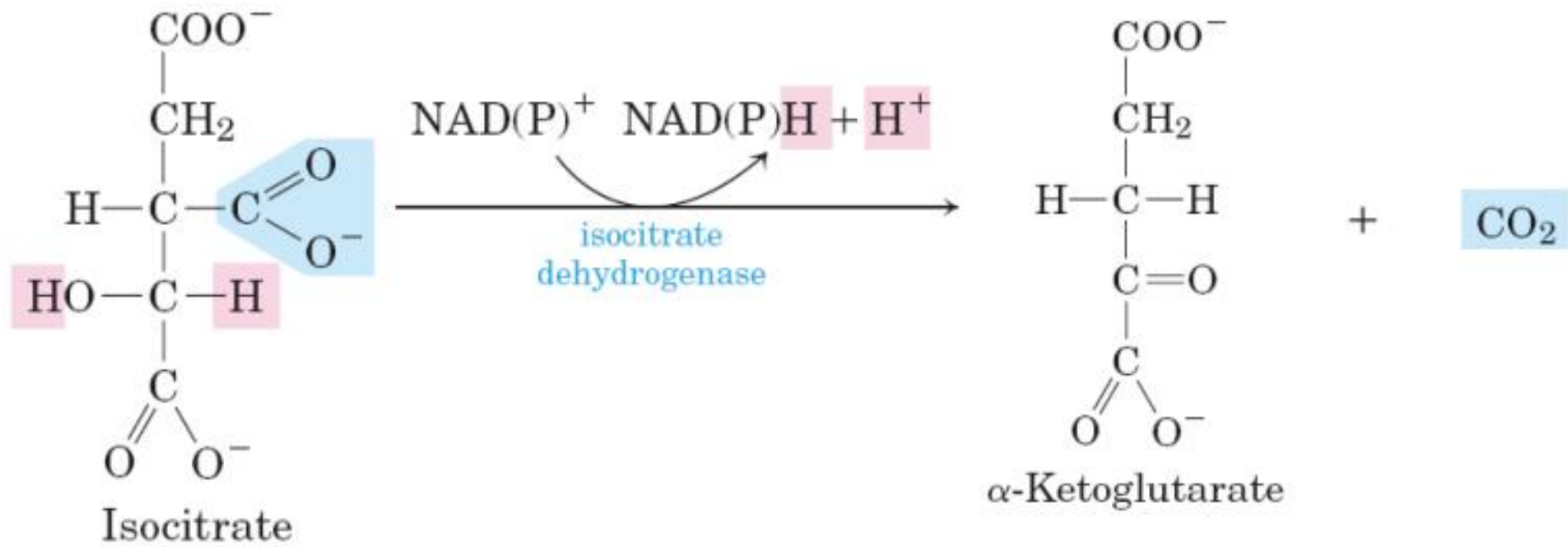
## مرحله ۲:





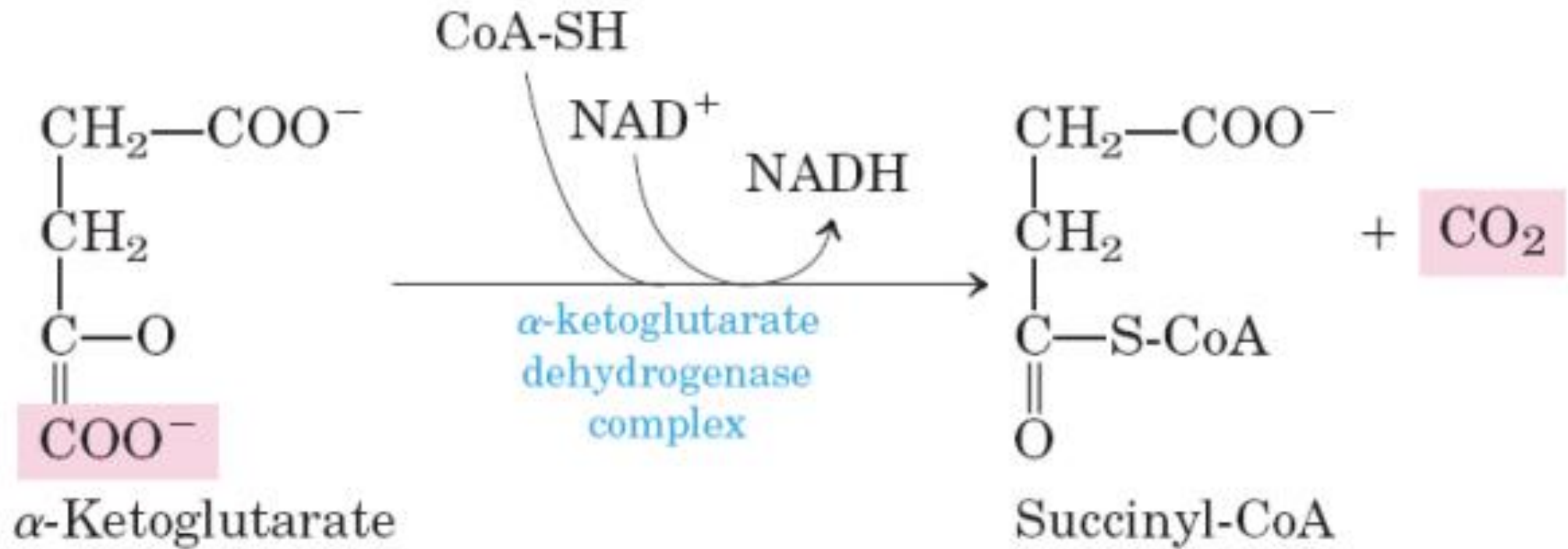
# چرخه اسید سیتریک

## مرحله ۳:



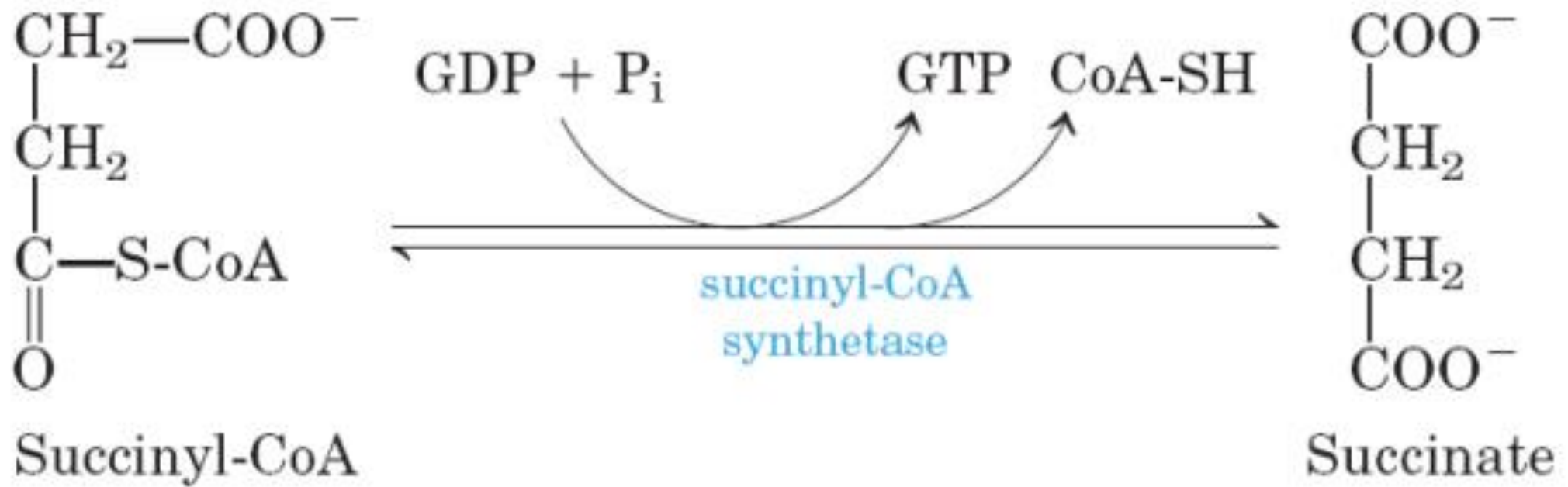
# چرخه اسید سیتریک

## مرحله ۴:



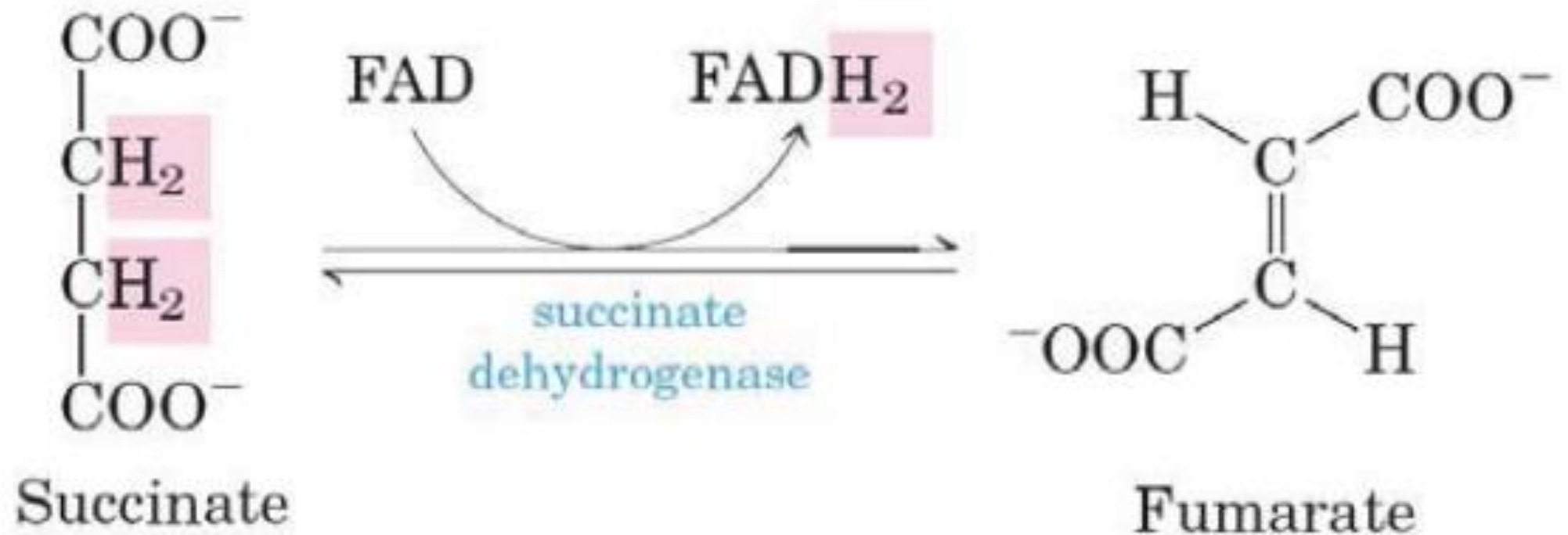
# چرخه اسید سیتریک

## مرحله ۵:



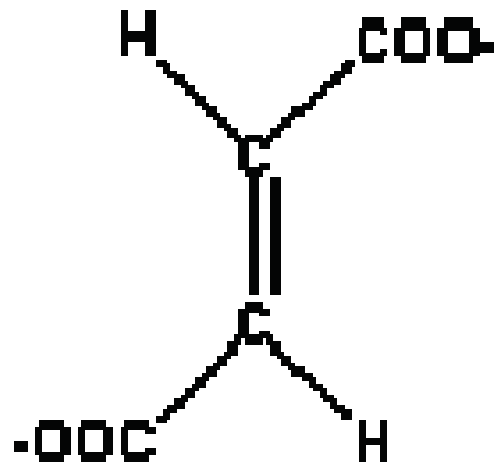
# چرخه اسید سیتریک

## مرحله ۶:

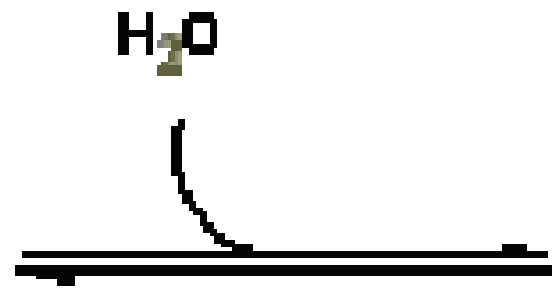


# چرخه اسید سیتریک

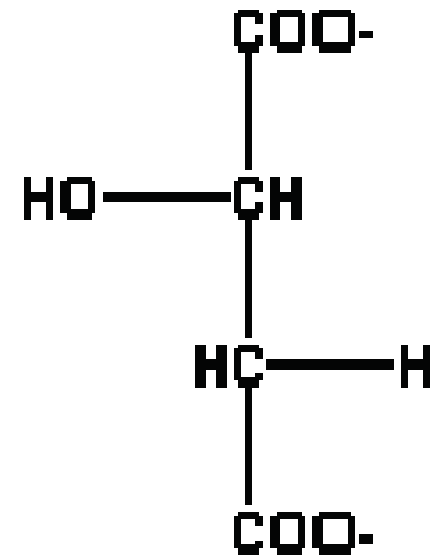
## مرحله ۷:



4C



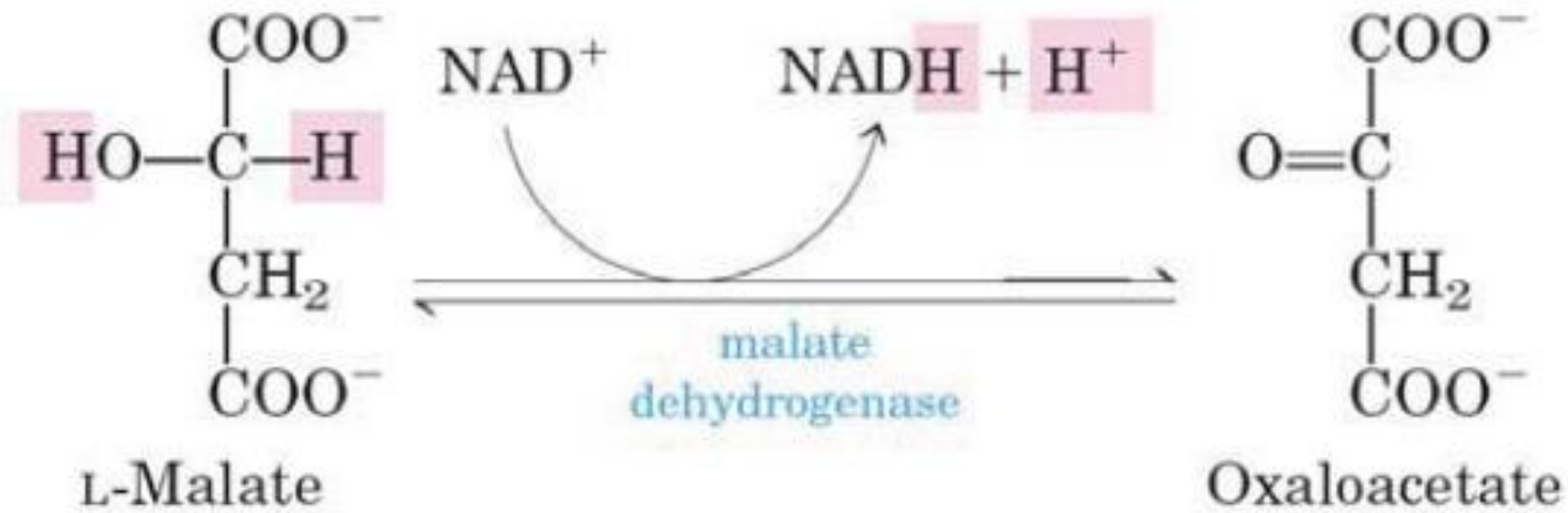
reversible



L-malate (4C)

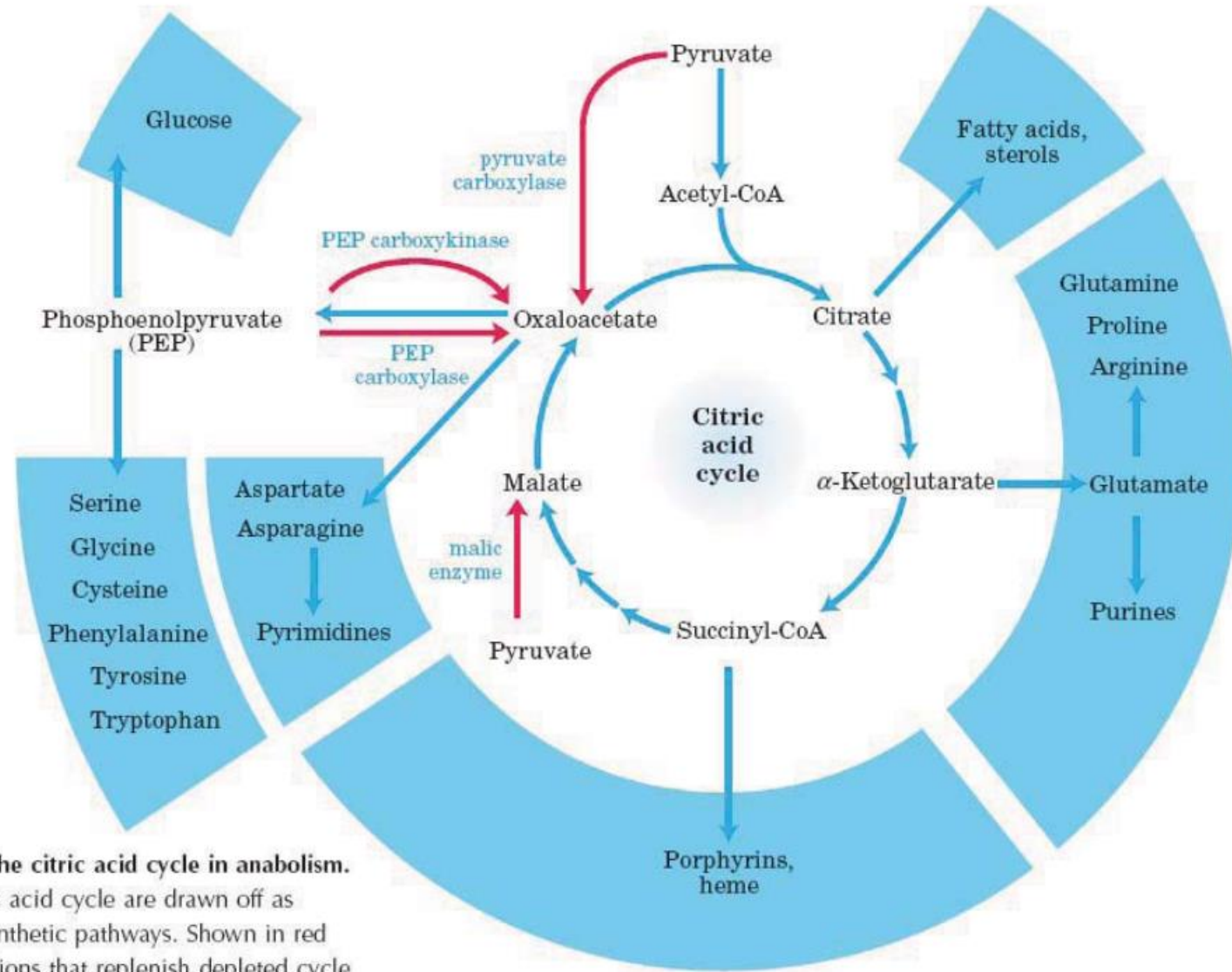
# چرخه اسید سیتریک

## مرحله ۸:



$$\Delta G'^{\circ} = 29.7 \text{ kJ/mol}$$

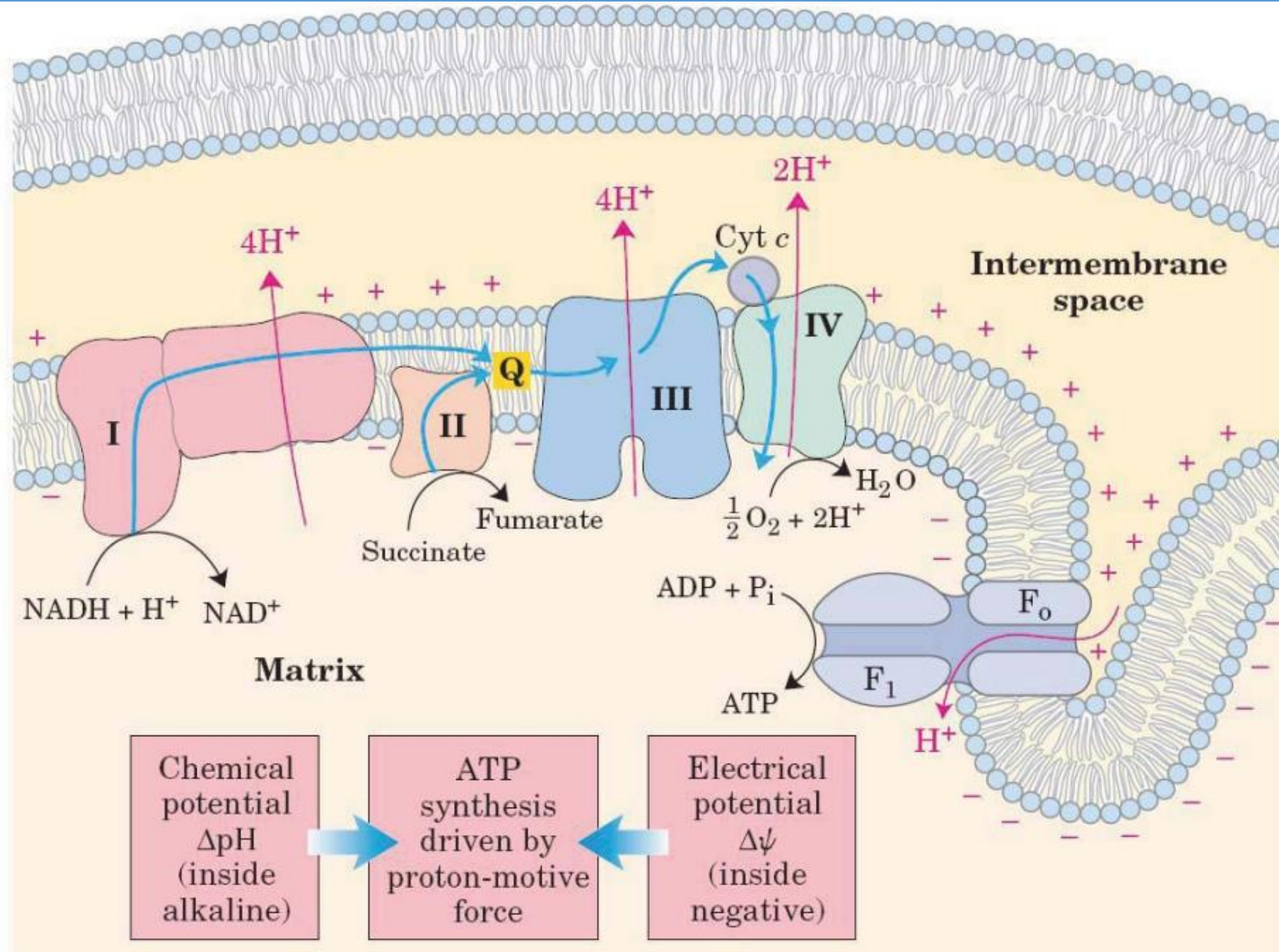
# نقش چرخه اسید سیتریک در آنابولیزم:



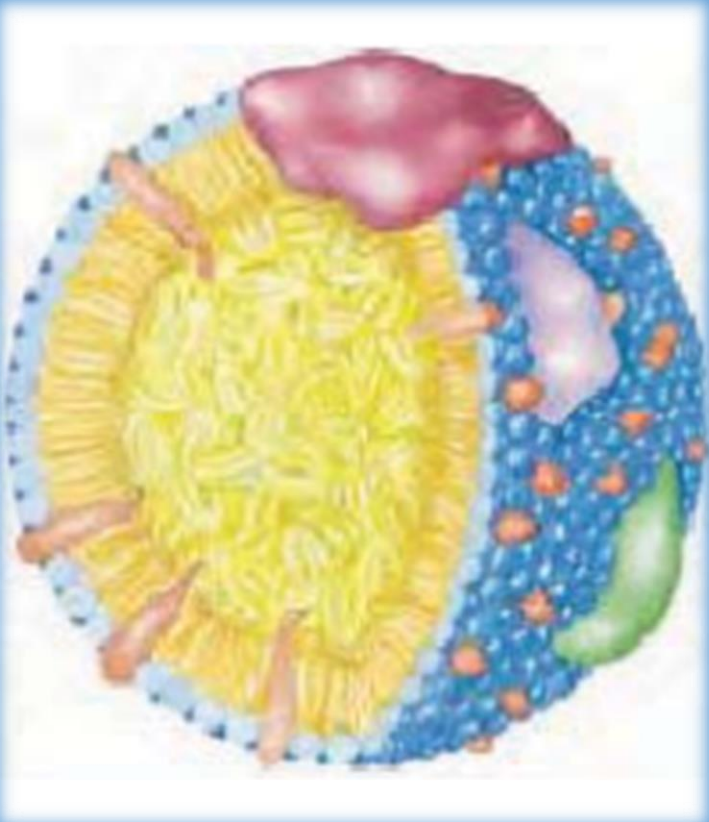
**FIGURE 16-15** Role of the citric acid cycle in anabolism. Intermediates of the citric acid cycle are drawn off as precursors in many biosynthetic pathways. Shown in red are four anaplerotic reactions that replenish depleted cycle intermediates



# سنتز ATP از انرژی حاصل از حاملین الکترون:

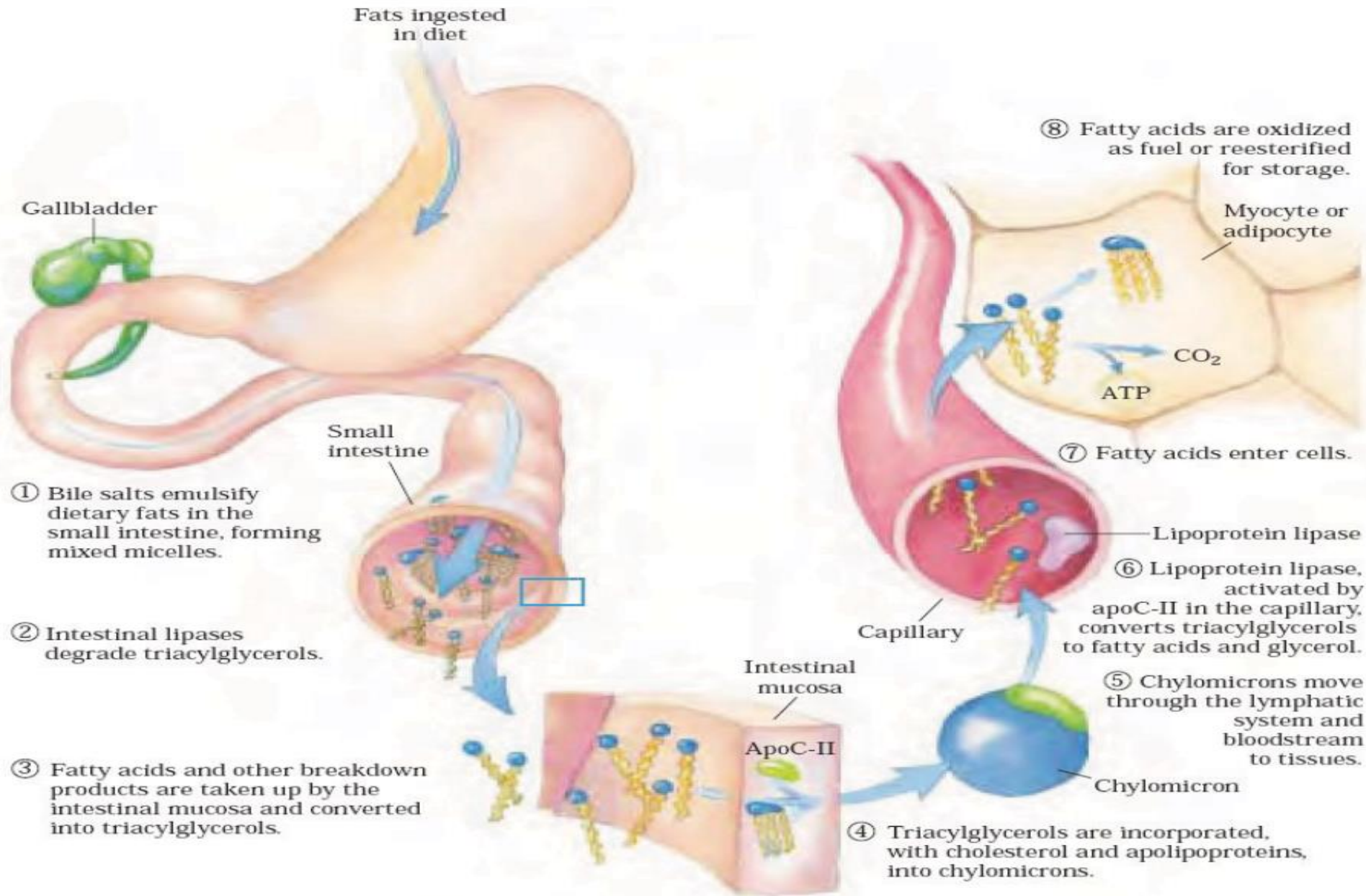


# متابولیسم لیپیدها: ✓



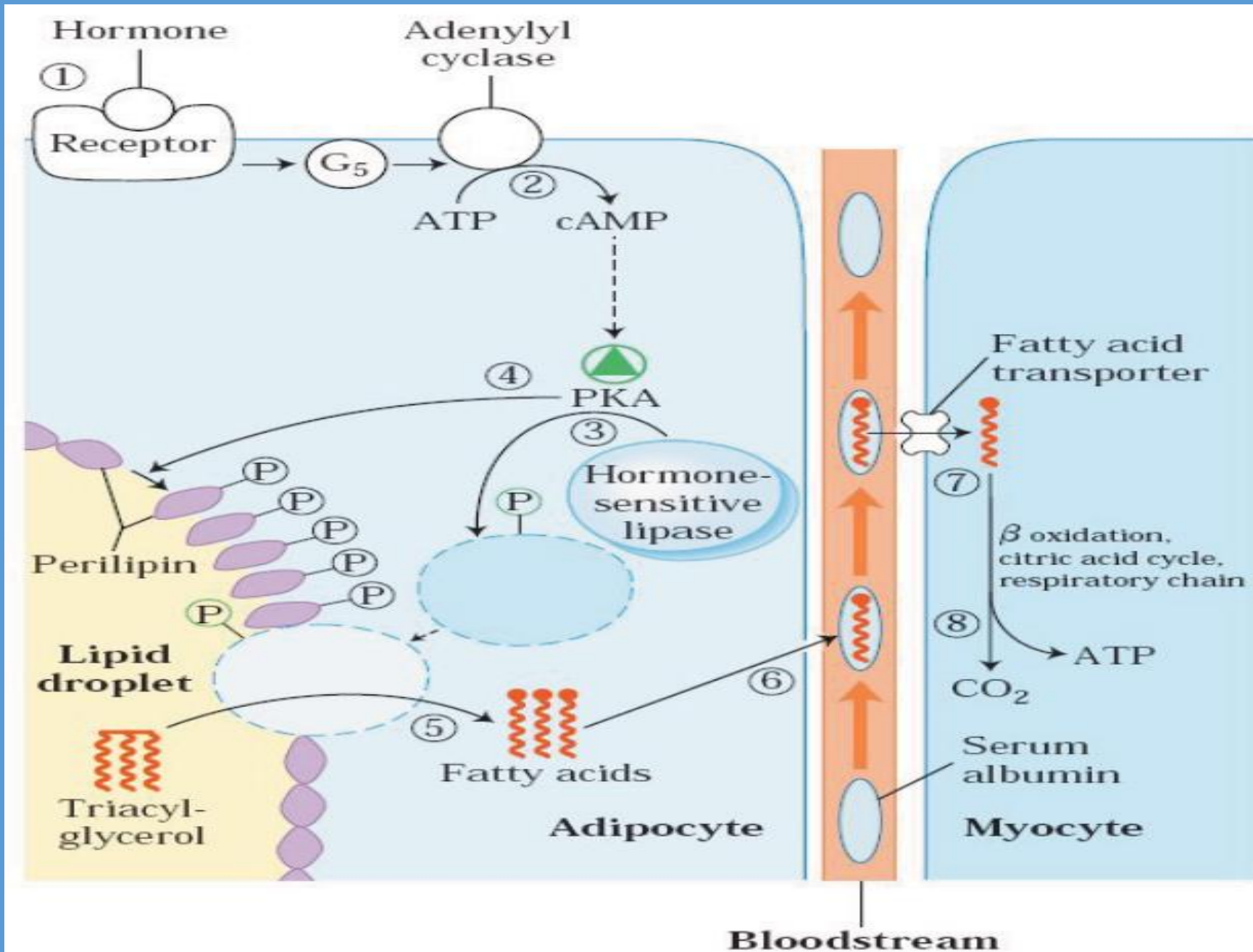
- مقدمه
- کاتابولیسم تری گلیسیریدها
- آنابولیسم تری گلیسیریدها

# پردازش لیپیدهای غذایی در مهره داران:

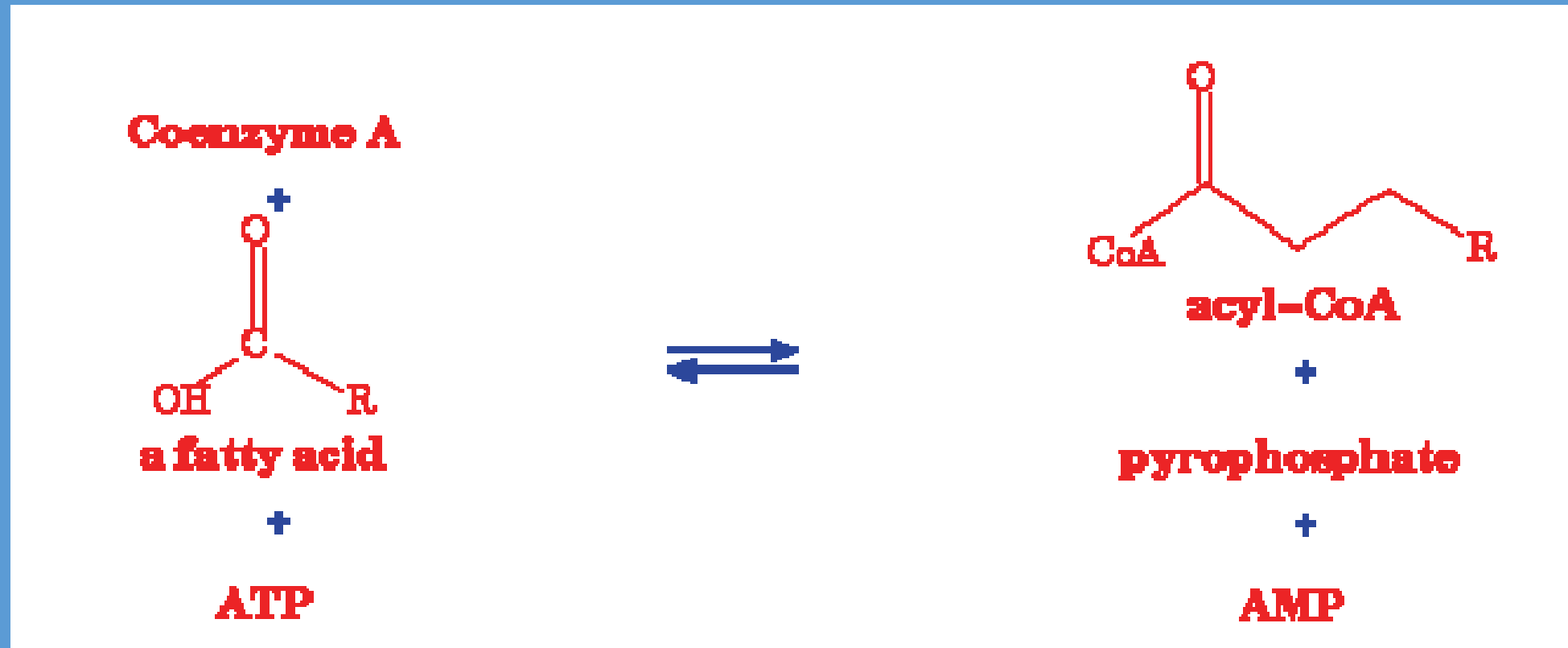




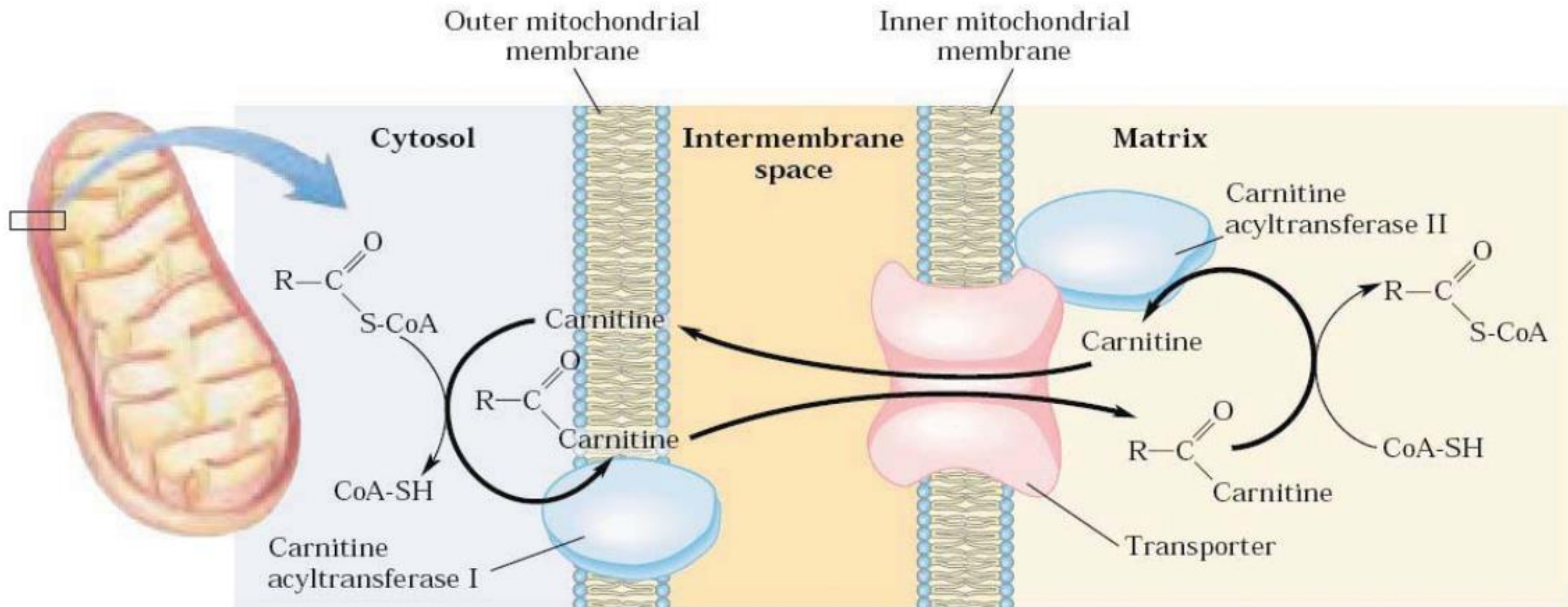
# پردازش تری گلیسرید ذخیره ای:



# اکسیداسیون اسیدهای چرب:

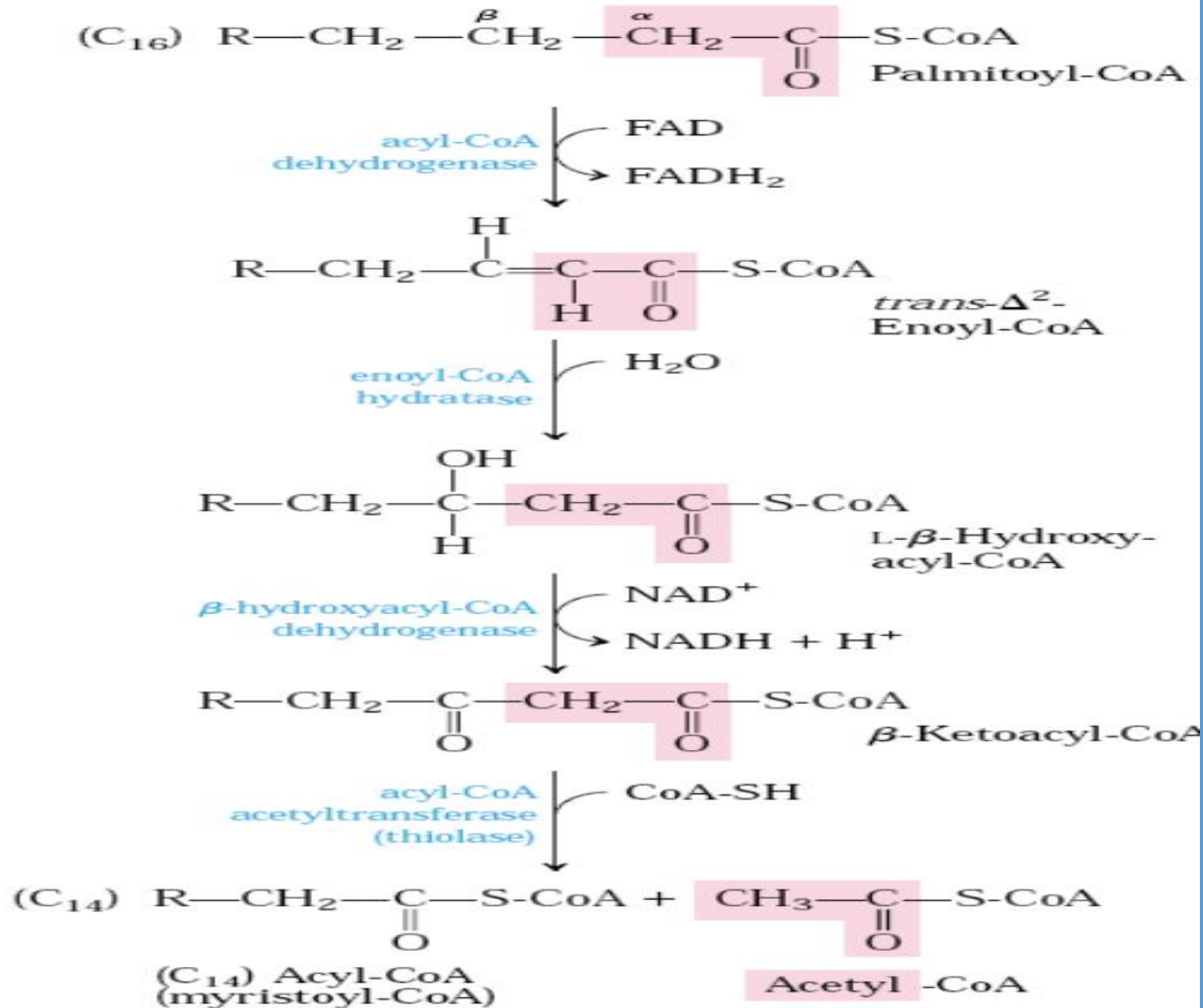


# ورود اسید چرب به داخل میتوکندری:



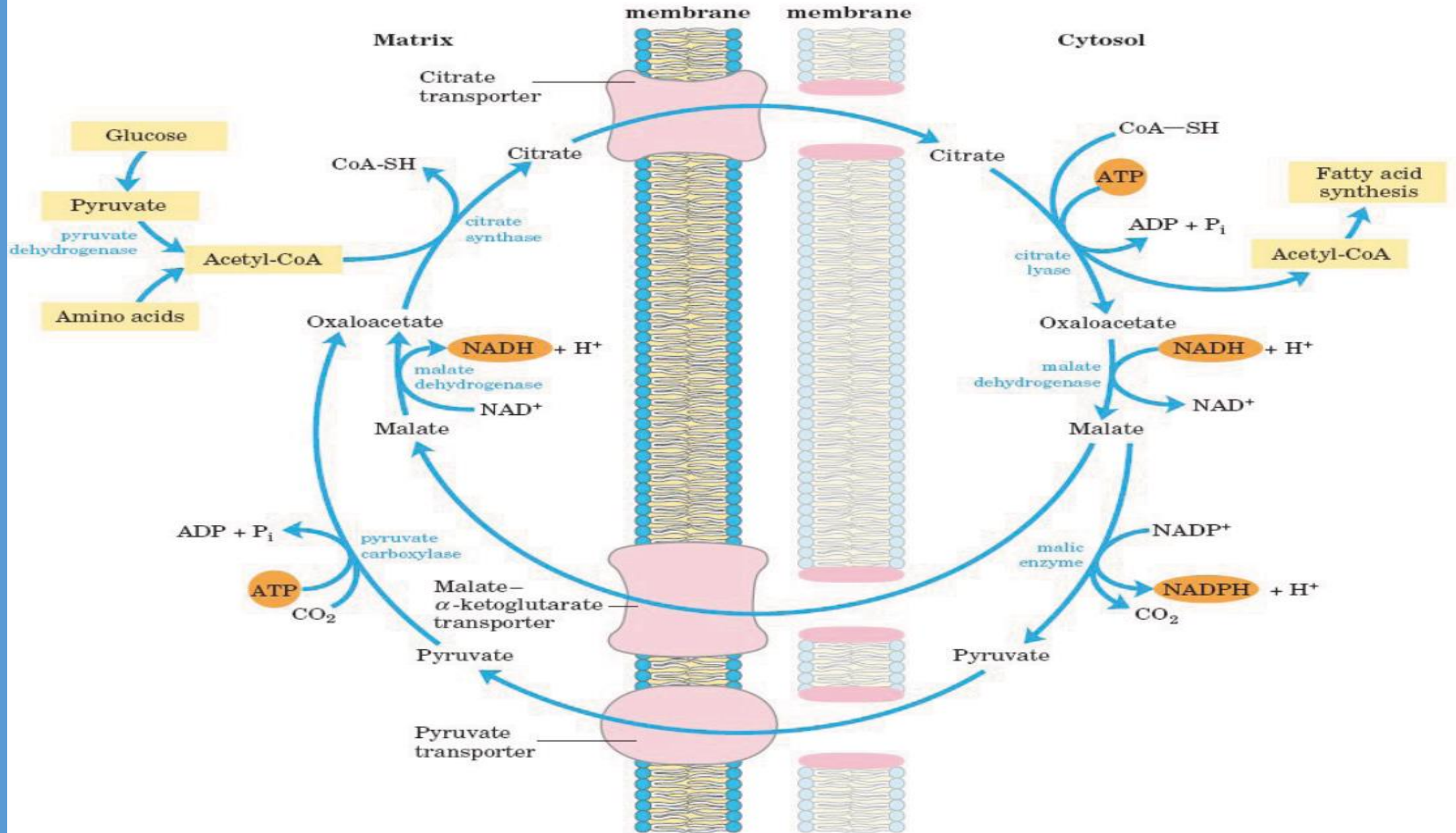
**FIGURE 17-6** Fatty acid entry into mitochondria via the acyl-carnitine/carnitine transporter.

# بتا اڪسيدا سيون:

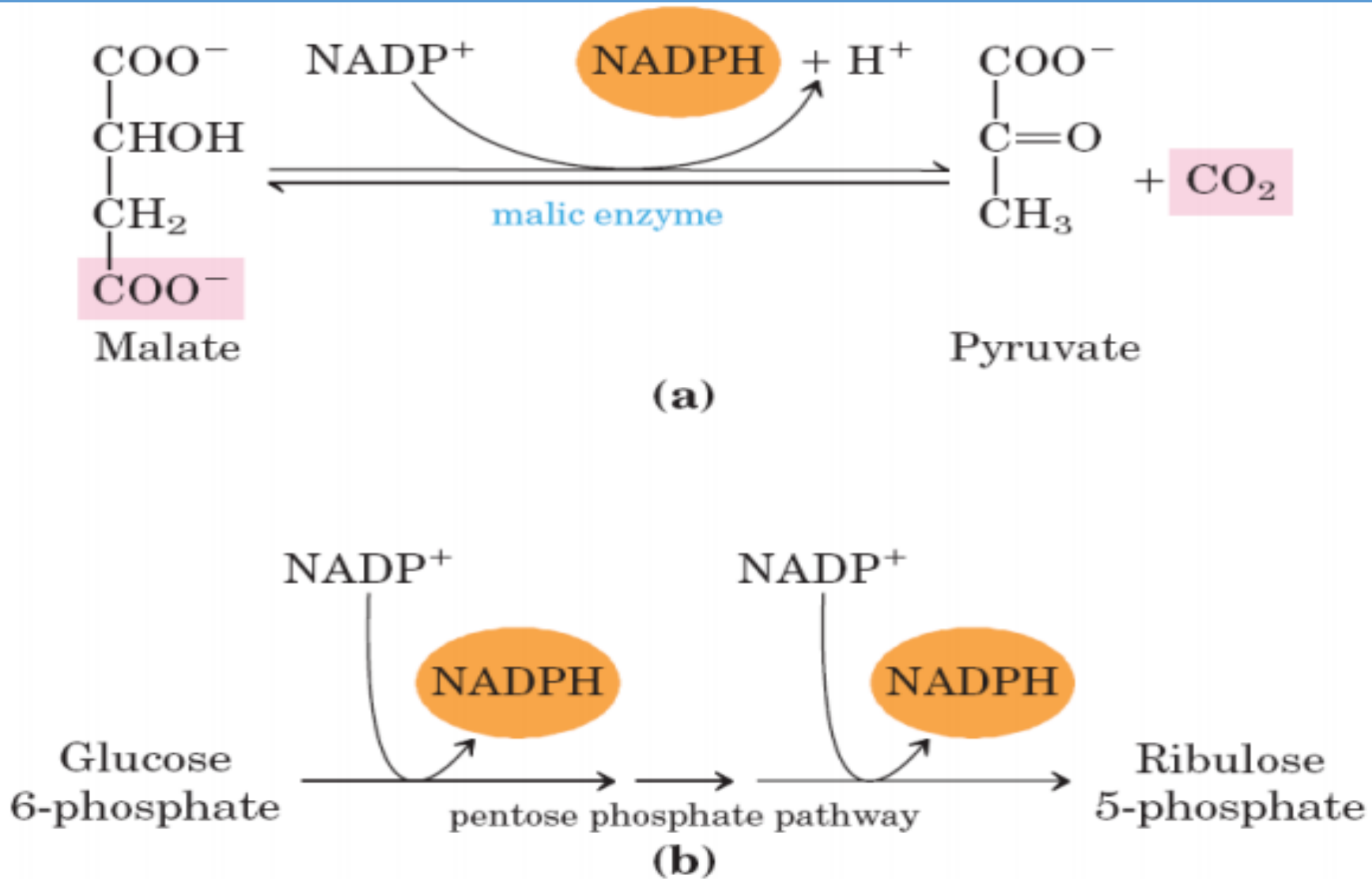




# بیوسنتز لیپیدها:

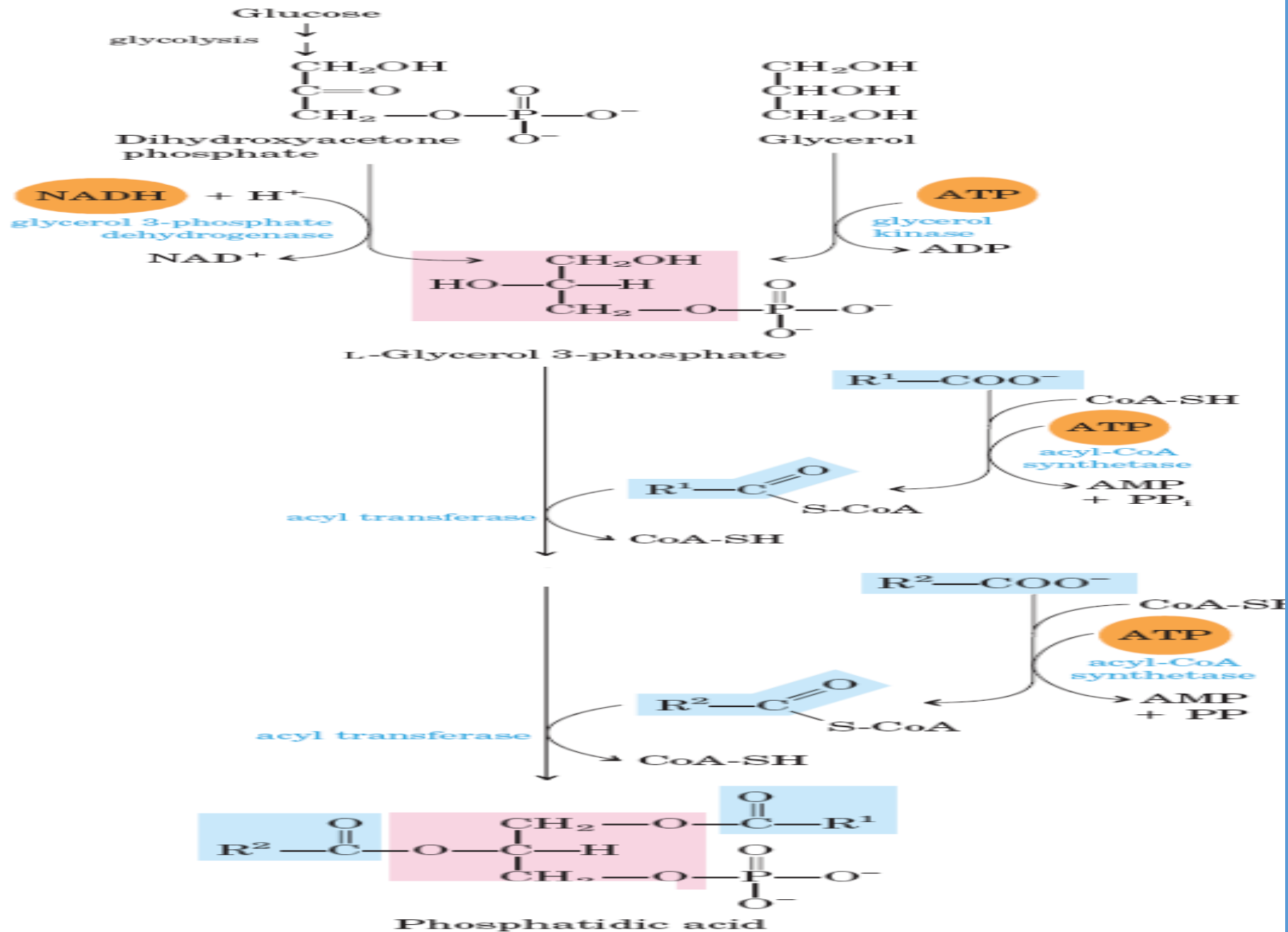


## :NADPH منابع

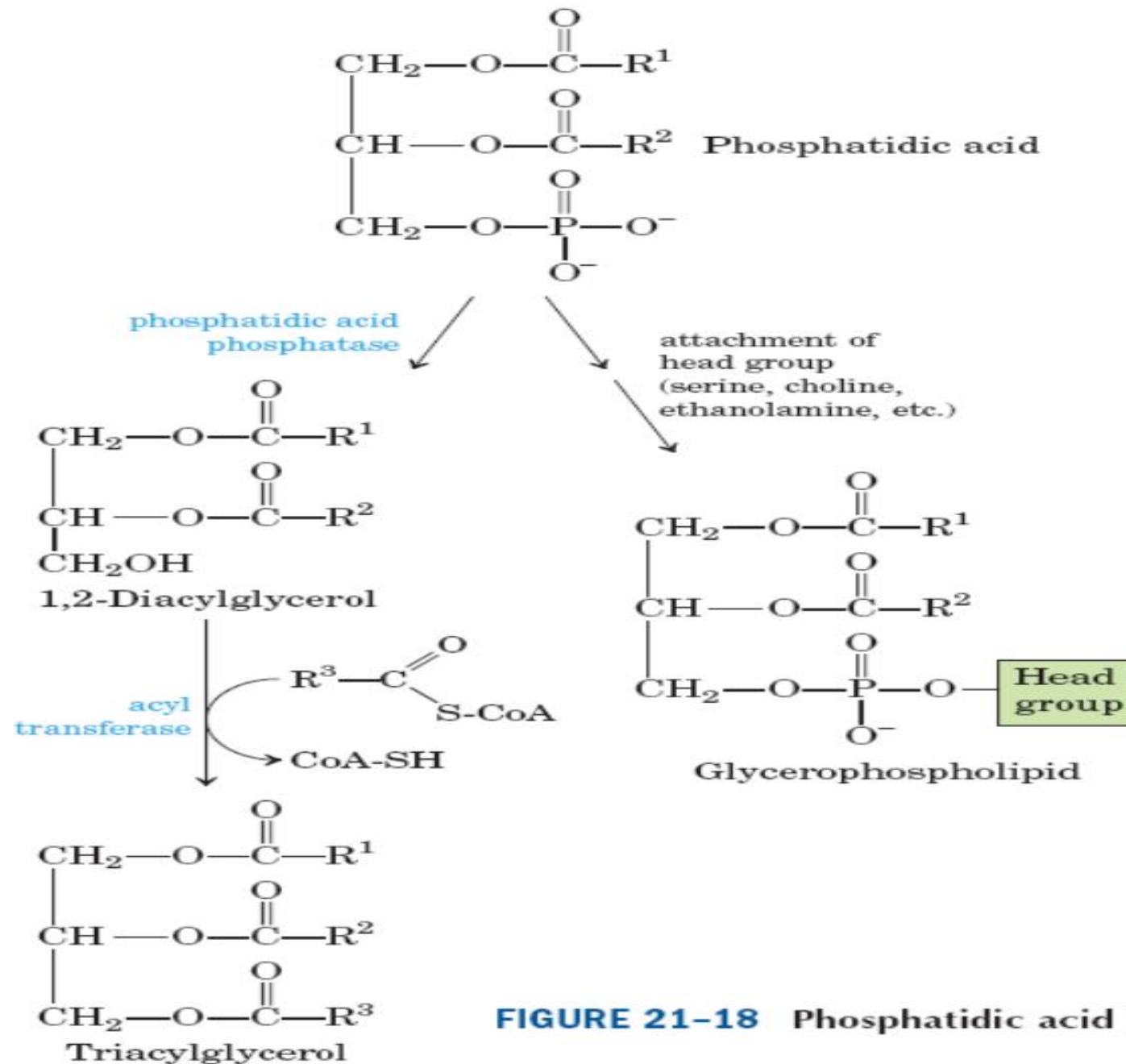


**FIGURE 21-9** Production of NADPH. Two routes to NADPH, catalyzed by (a) malic enzyme and (b) the pentose phosphate pathway.

# سنتز فسفاتیدیک اسید:

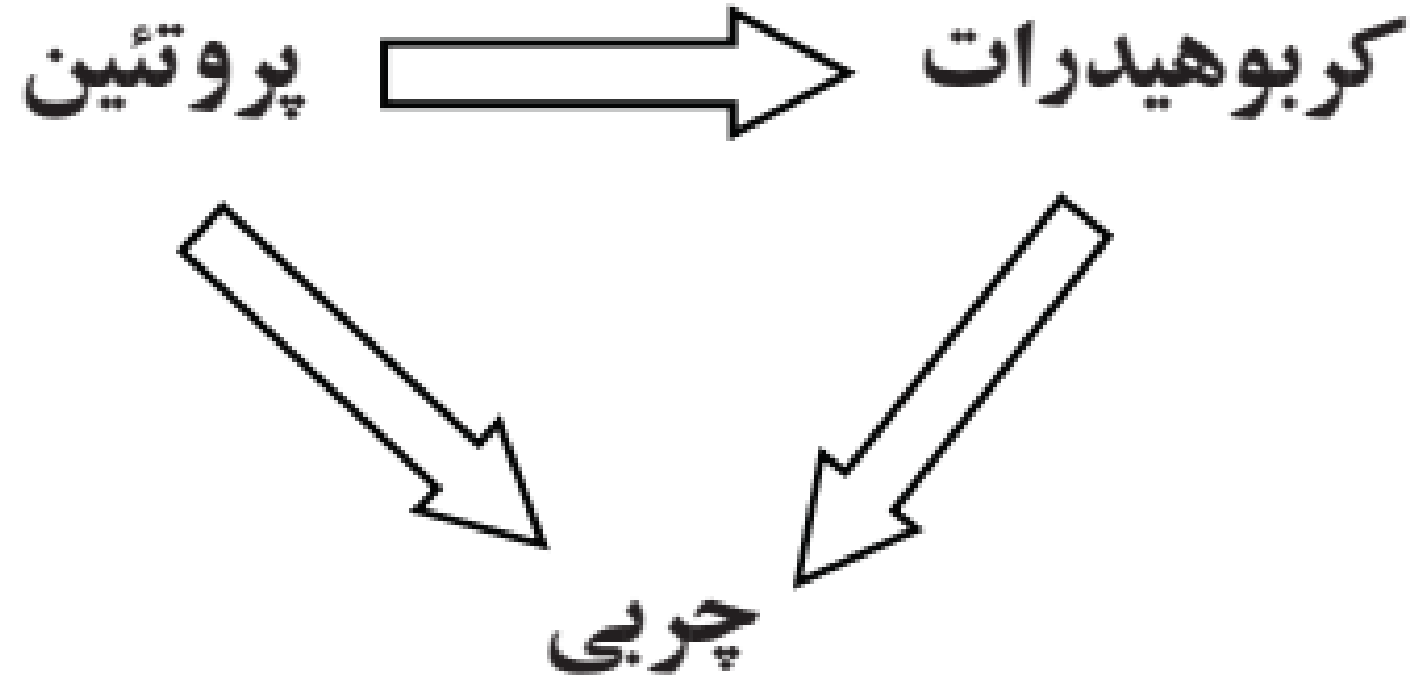


# سنتز فسفاتیدیک اسید:

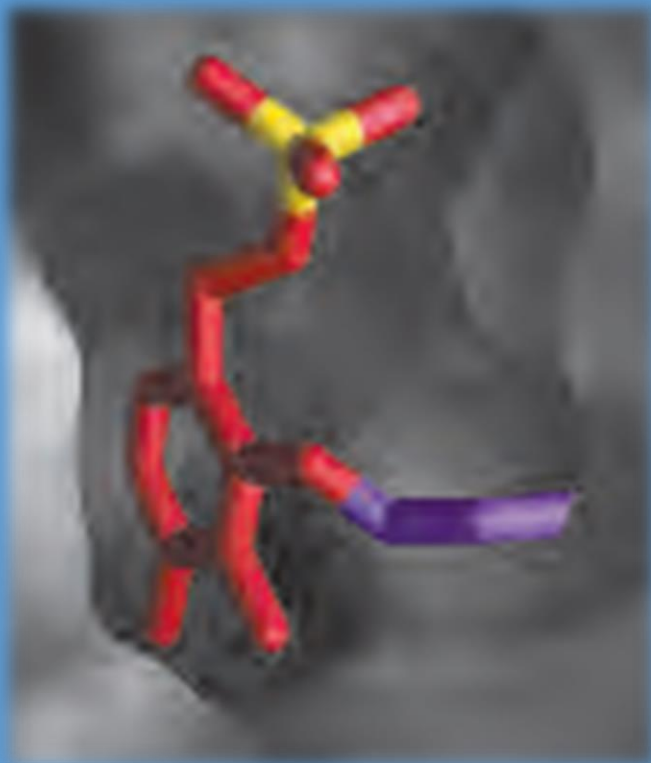


**FIGURE 21-18** Phosphatidic acid in lipid biosynthesis.

# مسیر مجاز تبدیل ماکرومولکولها:

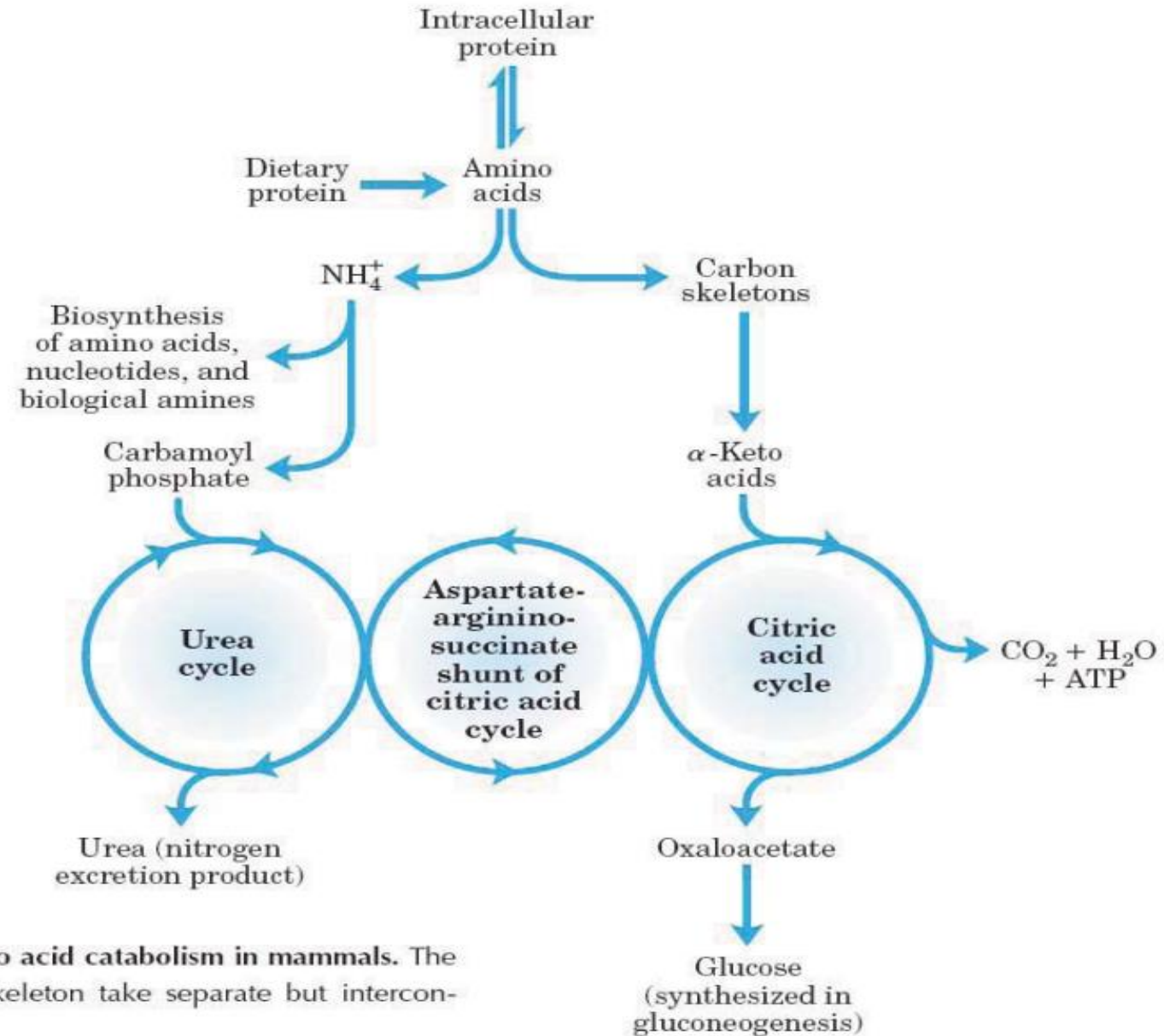


# متابولیسم اسیدهای آمینه: ✓



- مقدمه
- کاتابولیسم آمینواسیدها
- آنابولیسم آمینواسیدها

# کاتابولیزم آمینواسیدها:

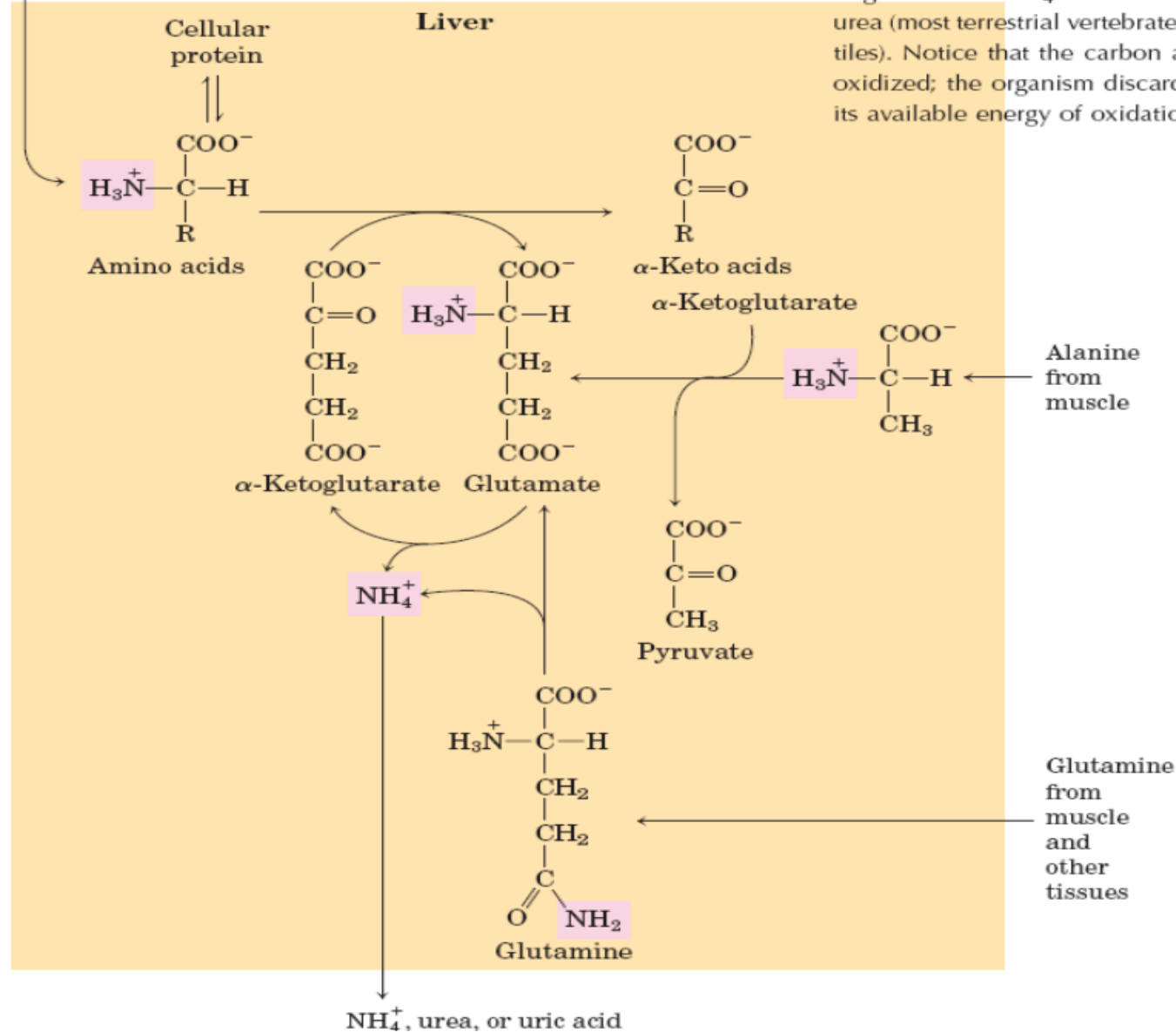


**FIGURE 18-1** Overview of amino acid catabolism in mammals. The amino groups and the carbon skeleton take separate but interconnected pathways.



# کاتابولیزم آمینواسیدها:

Amino acids from ingested protein



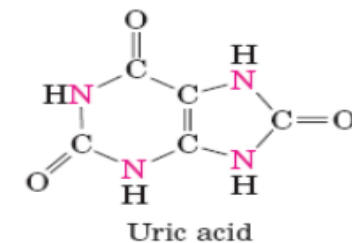
**FIGURE 18-2 Amino group catabolism.** (a) Overview of catabolism of amino groups (shaded) in vertebrate liver. (b) Excretory forms of nitrogen. Excess  $\text{NH}_4^+$  is excreted as ammonia (microbes, bony fishes), urea (most terrestrial vertebrates), or uric acid (birds and terrestrial reptiles). Notice that the carbon atoms of urea and uric acid are highly oxidized; the organism discards carbon only after extracting most of its available energy of oxidation.



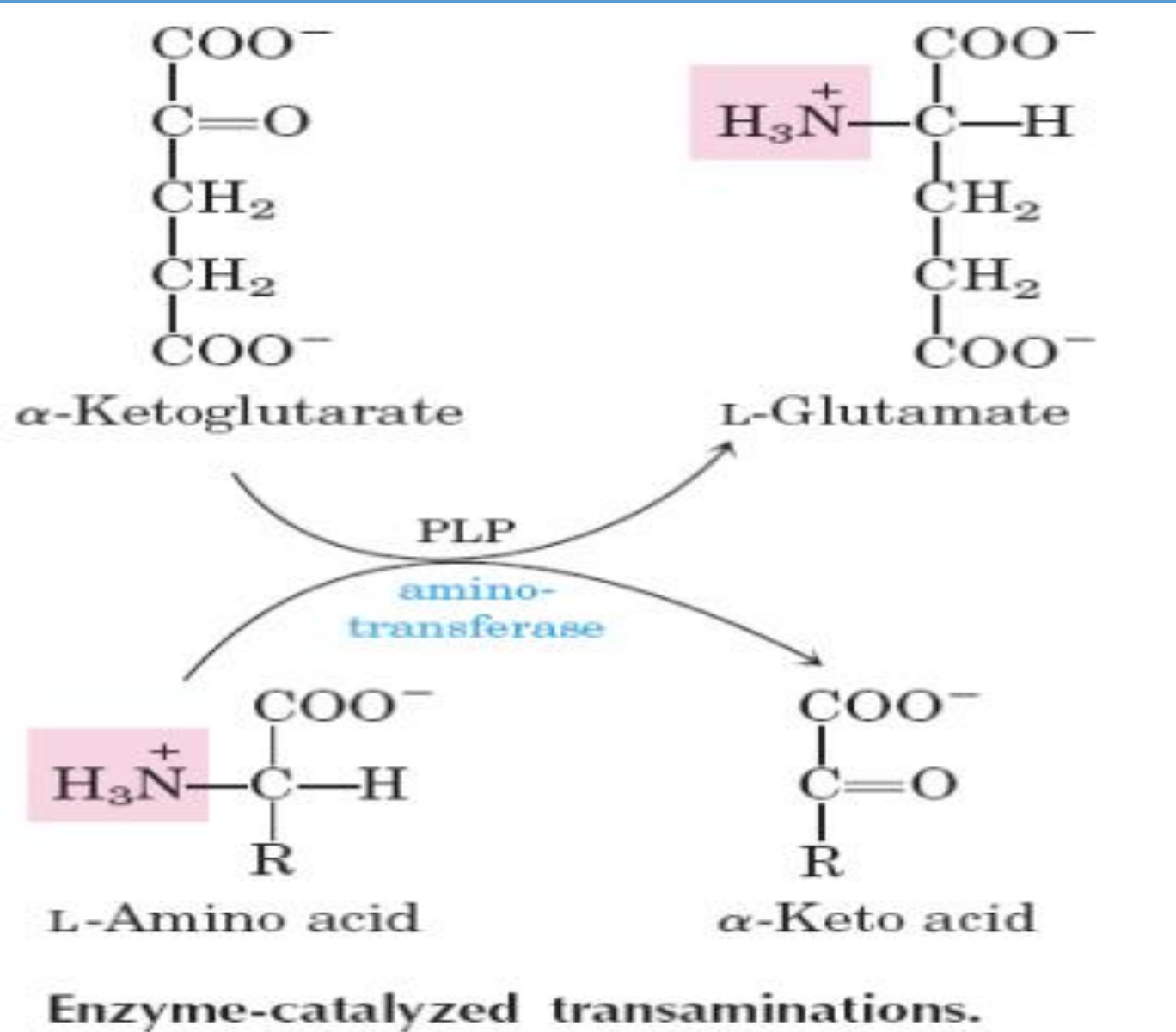
Ammonotelic animals: most aquatic vertebrates, such as bony fishes and the larvae of amphibia



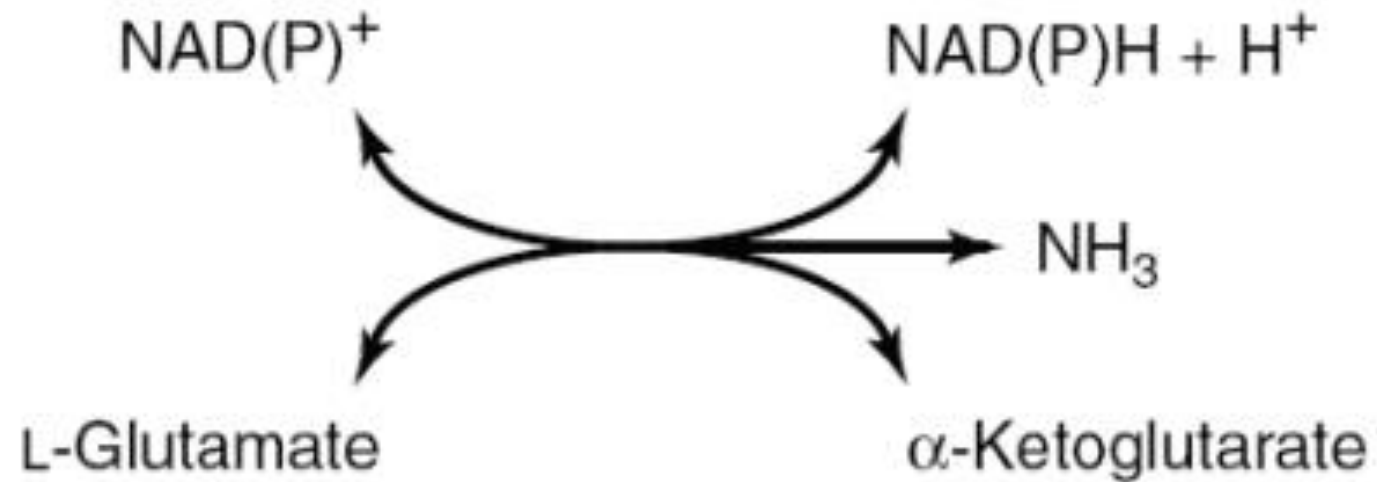
Ureotelic animals: many terrestrial vertebrates; also sharks



# کاتابولیزم آمینواسیدها:

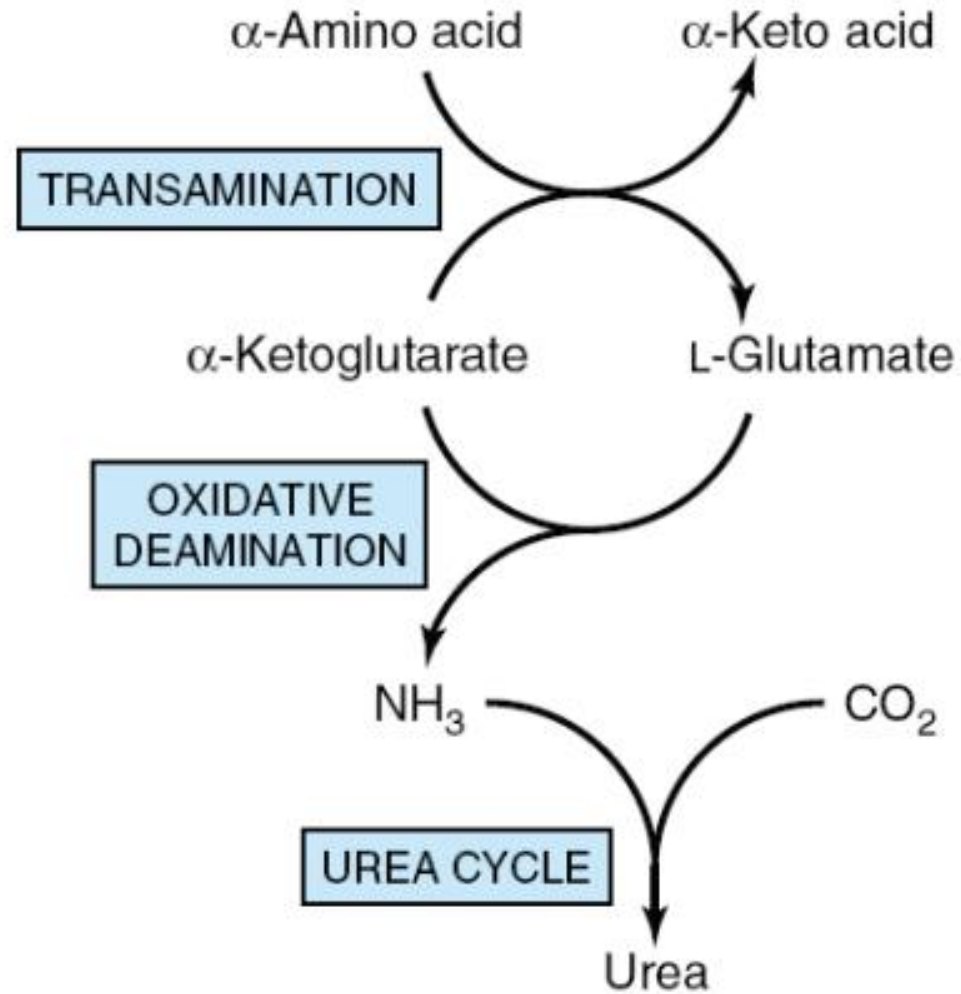


## کاتابولیسم آمینواسیدها:



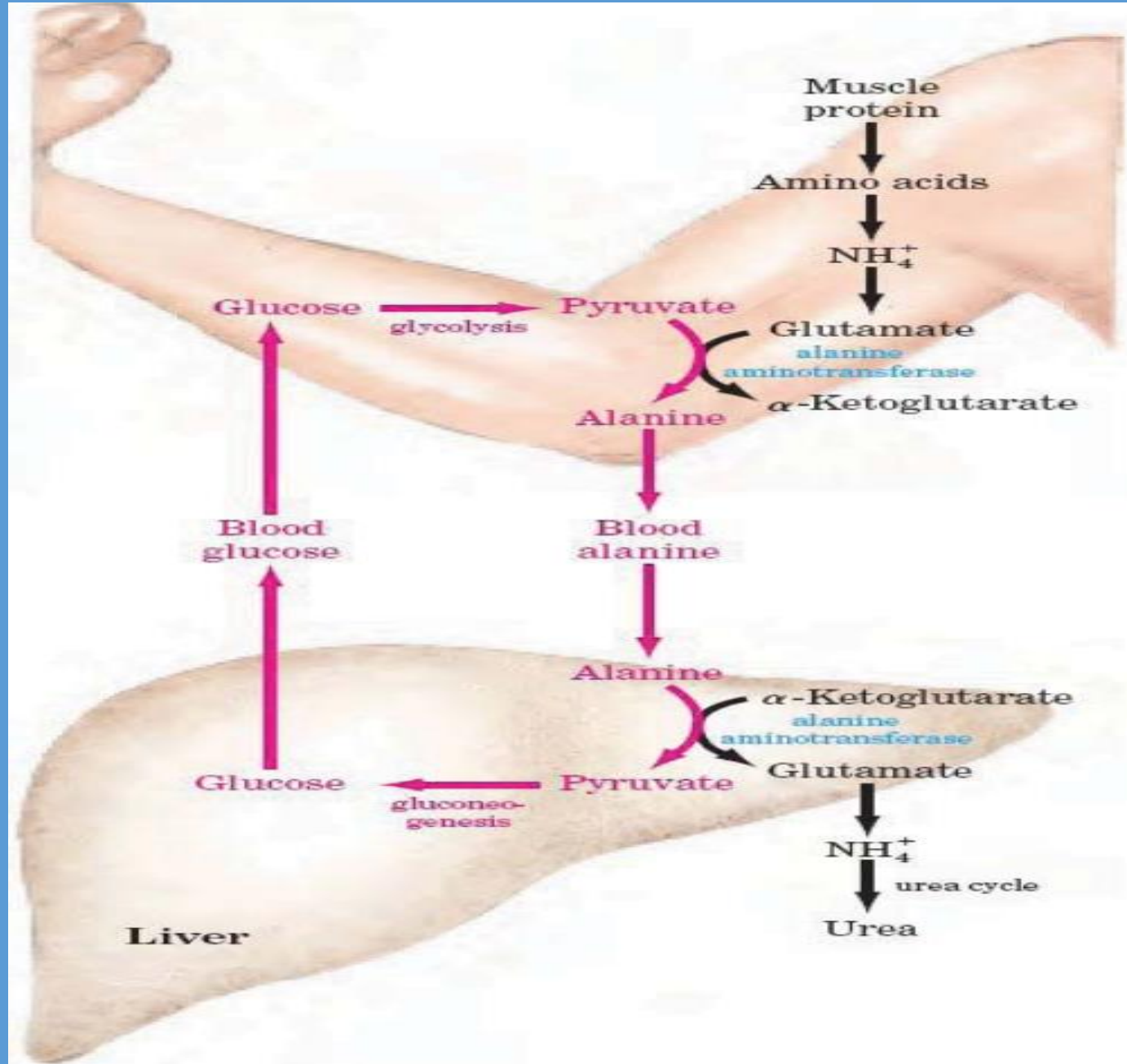
**Figure 29–5.** The L-glutamate dehydrogenase reaction.

# کاتابولیزم آمینو اسیدها:

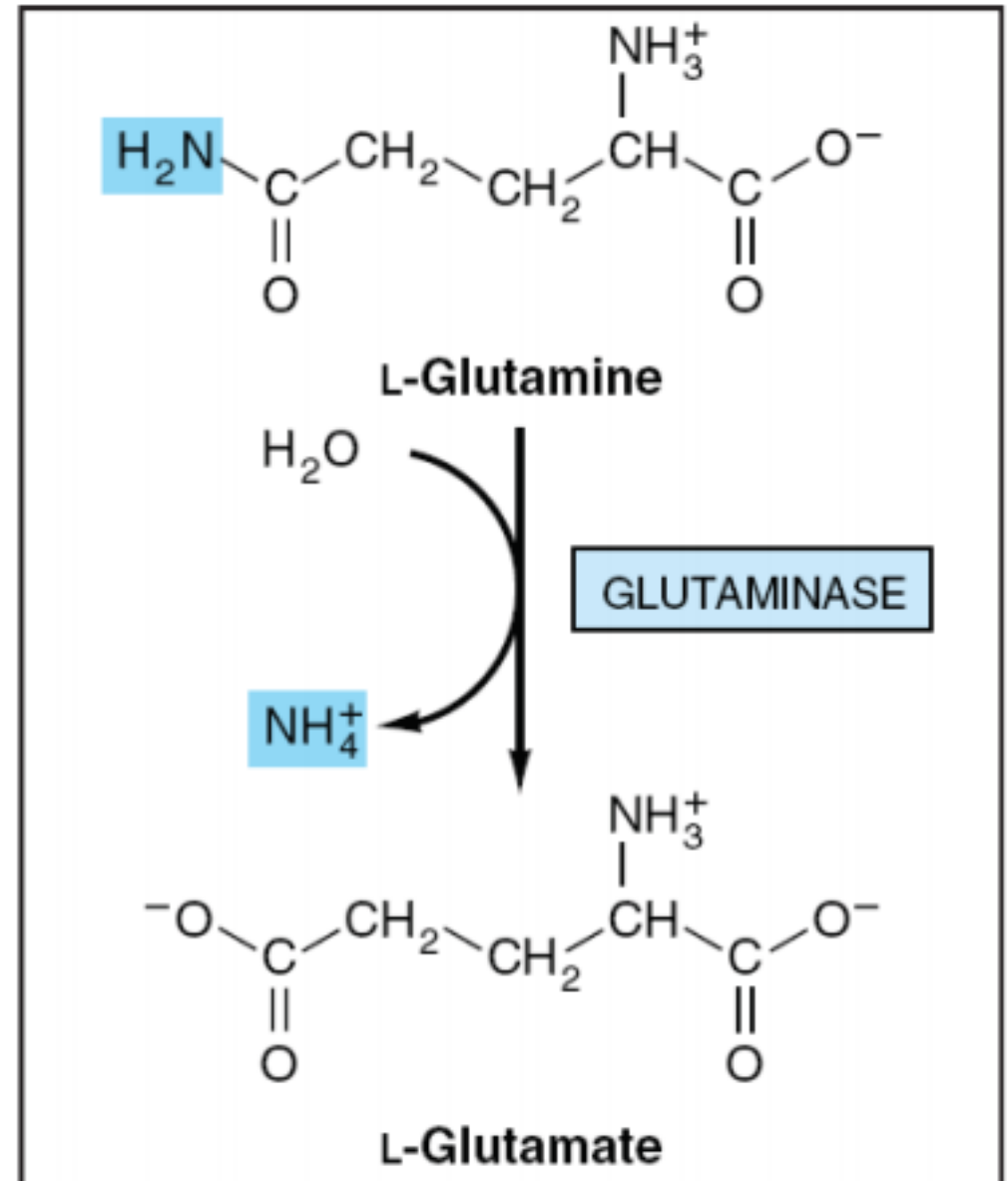
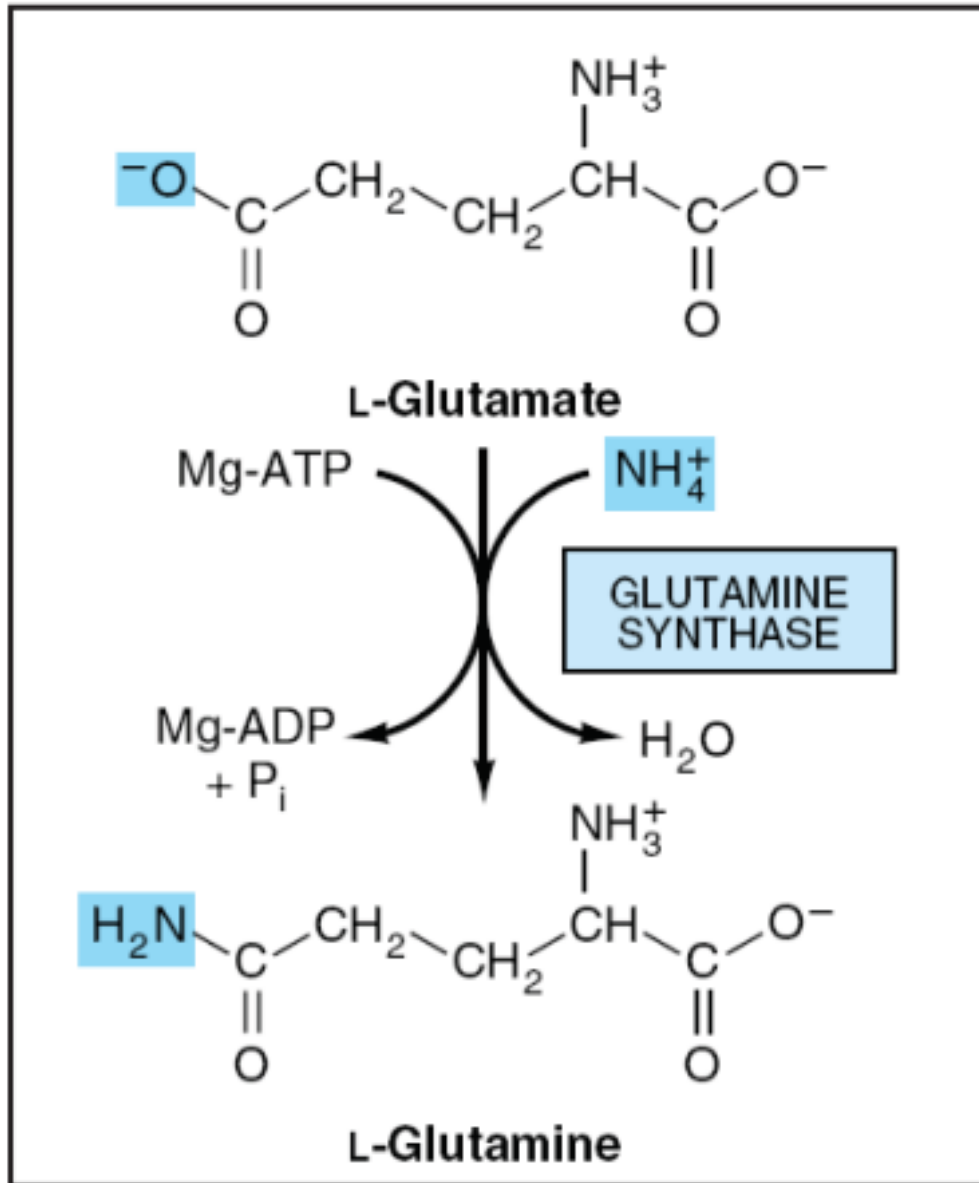


**Figure 29–2.** Overall flow of nitrogen in amino acid catabolism.

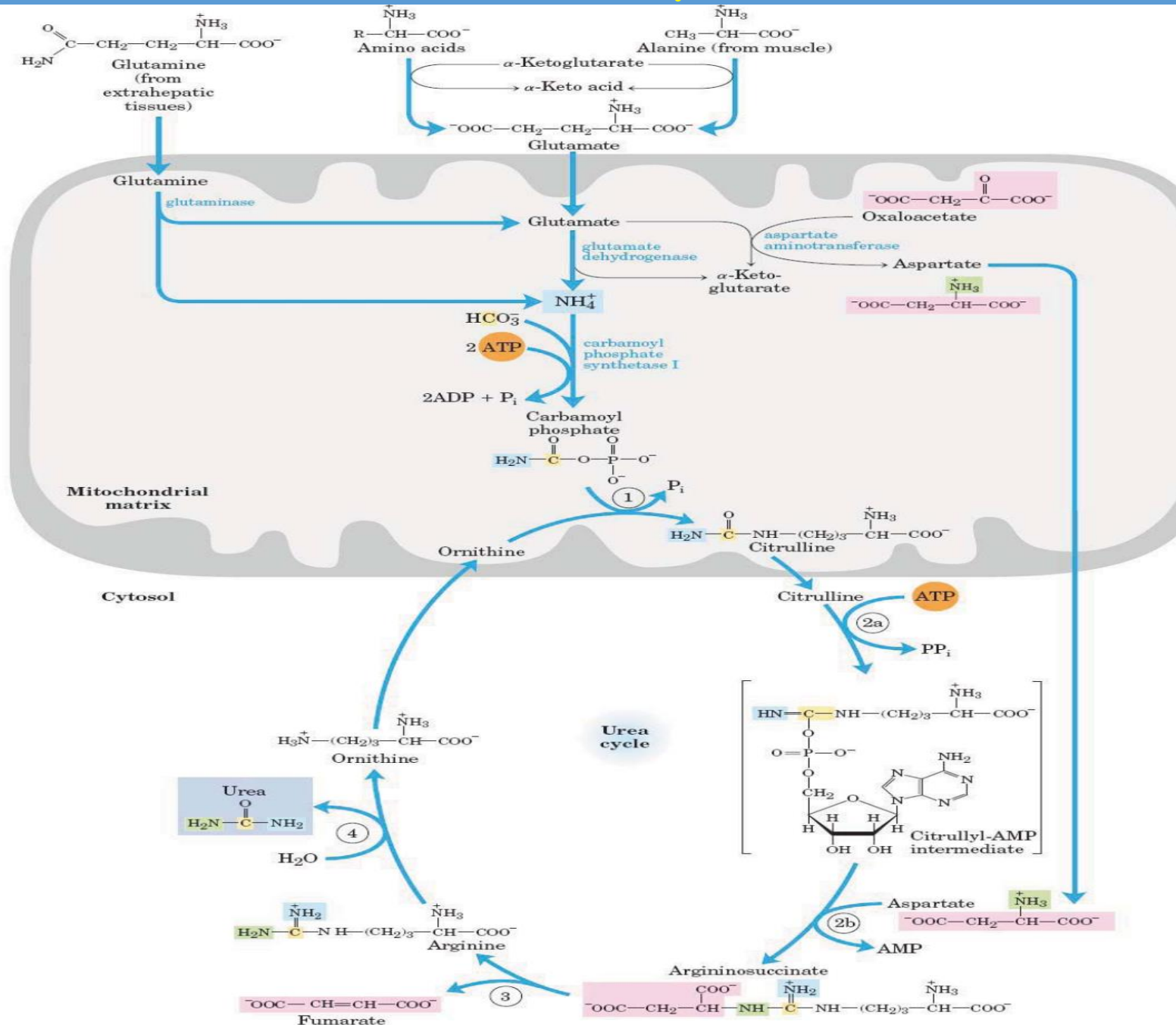
# دفع آمونیاک از ماهیچه:



# دفع آمونیاک از مغز:

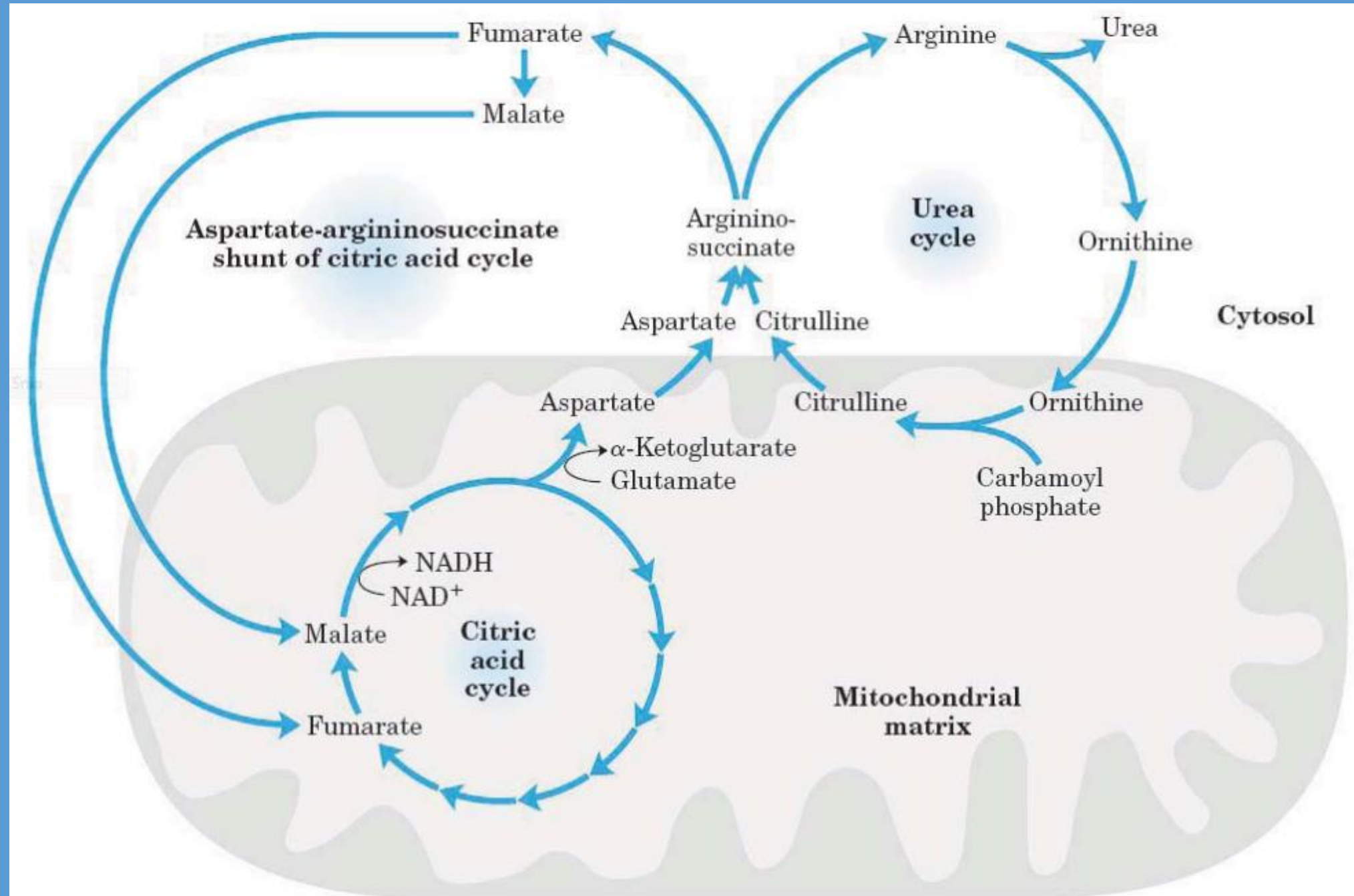


# چرخہ اورہ:

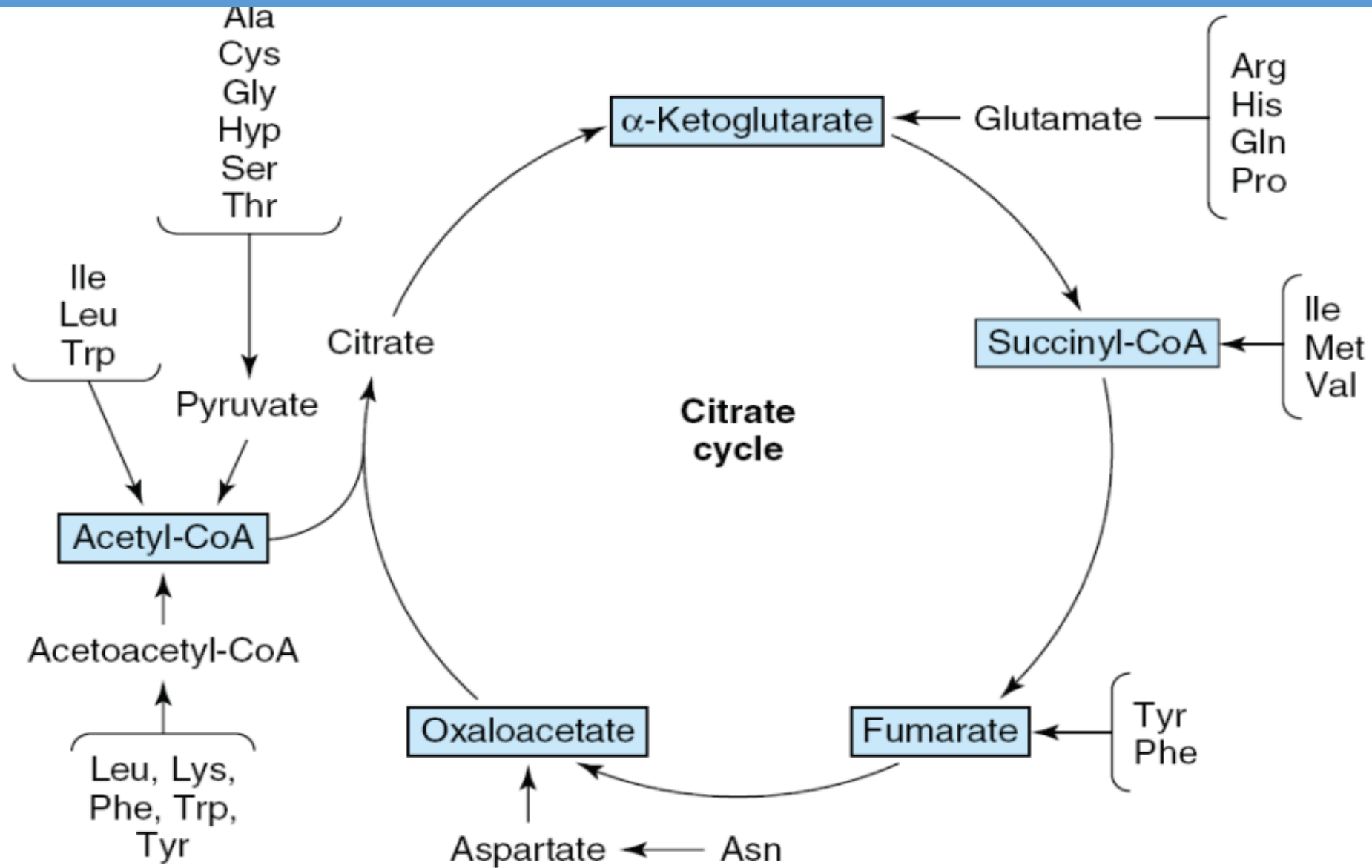




# ارتباط بین چرخه اوره و کربس:

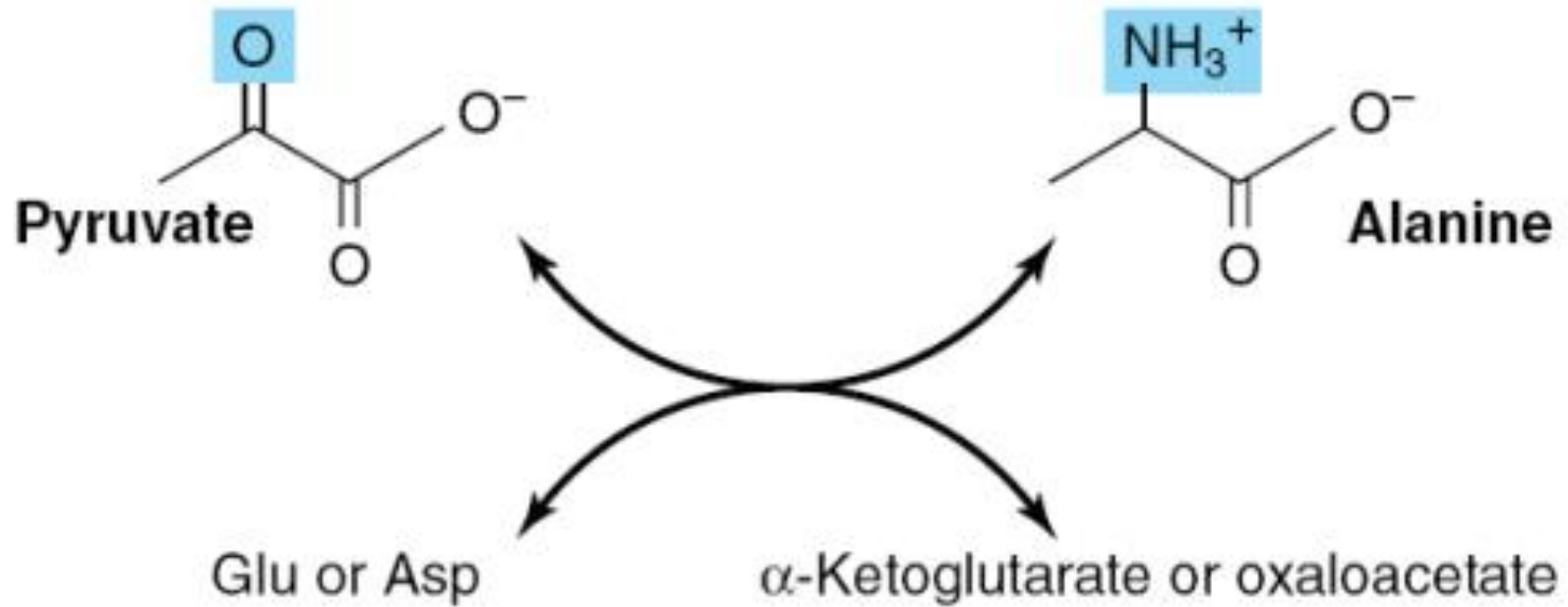


# تخریب اسکلت کربنی آمینواسیدها:

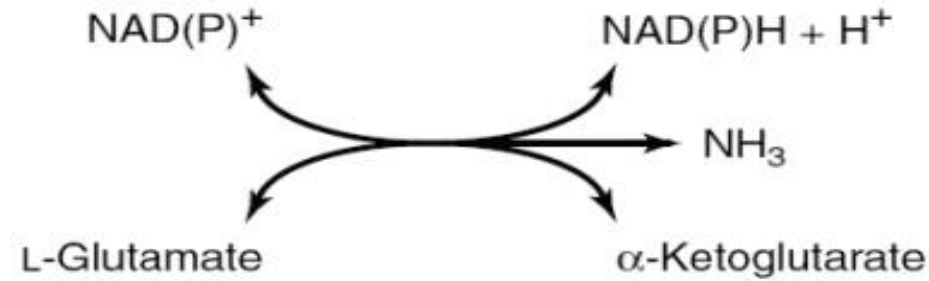


**Figure 30-1.** Amphibolic intermediates formed from the carbon skeletons of amino acids.

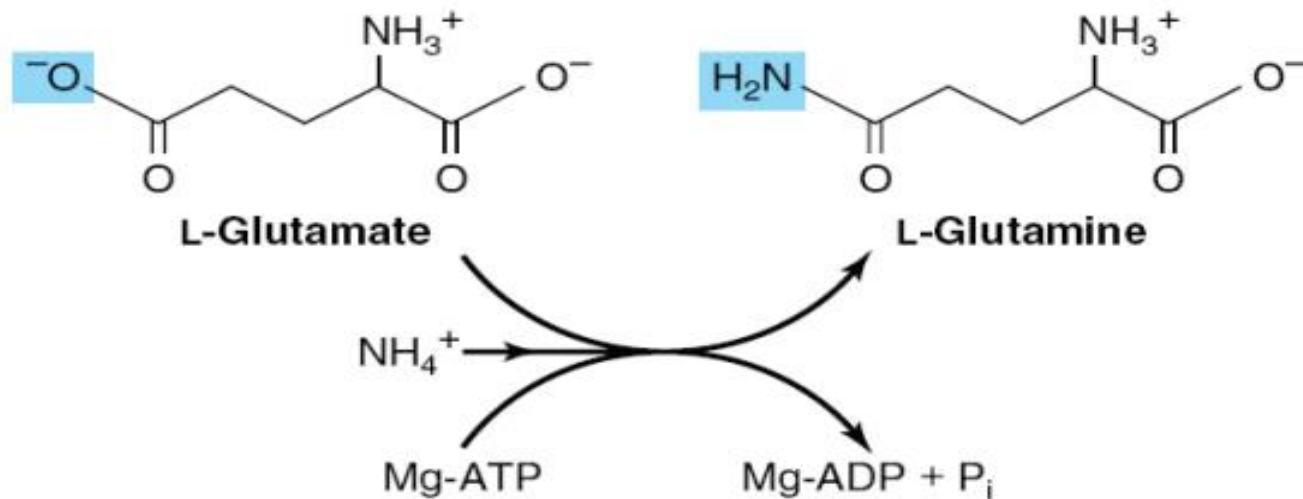
# بیوسنتز آمینواسیدها: (آلانین)



# بیوسنتز آمینواسیدها: (گلوتامات و گلوتامین)

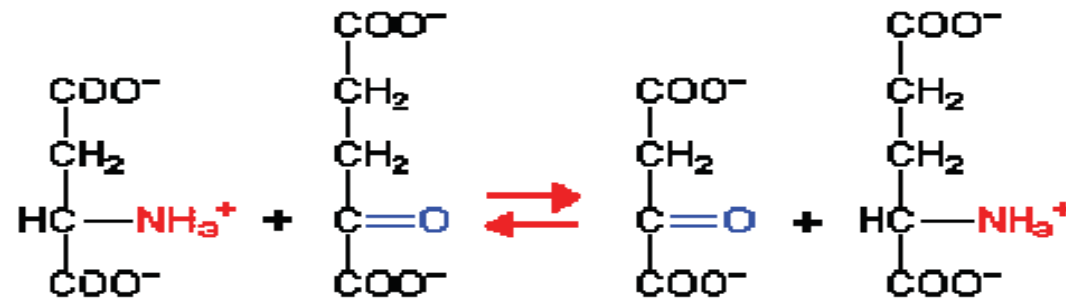


**Figure 29-5.** The L-glutamate dehydrogenase reaction.

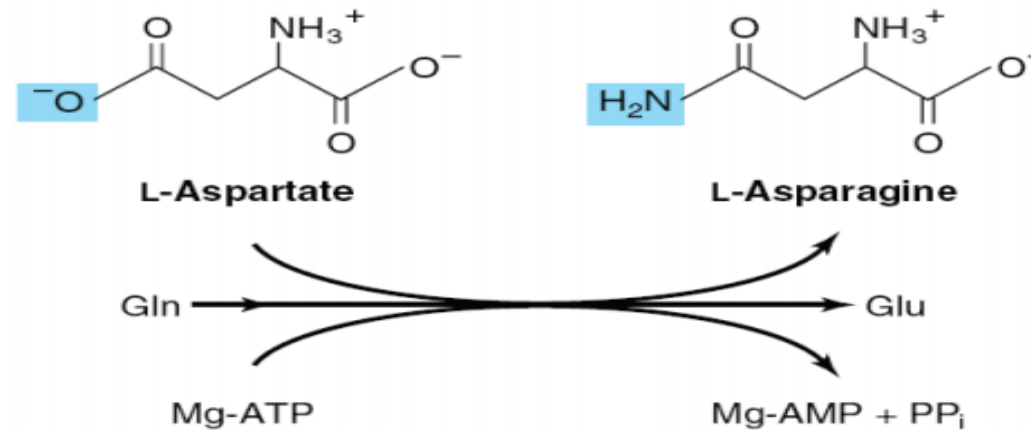


**Figure 28-2.** The glutamine synthetase reaction.

# بیوسنتز آمینواسیدها: (آسپارتات و آسپاراژین)

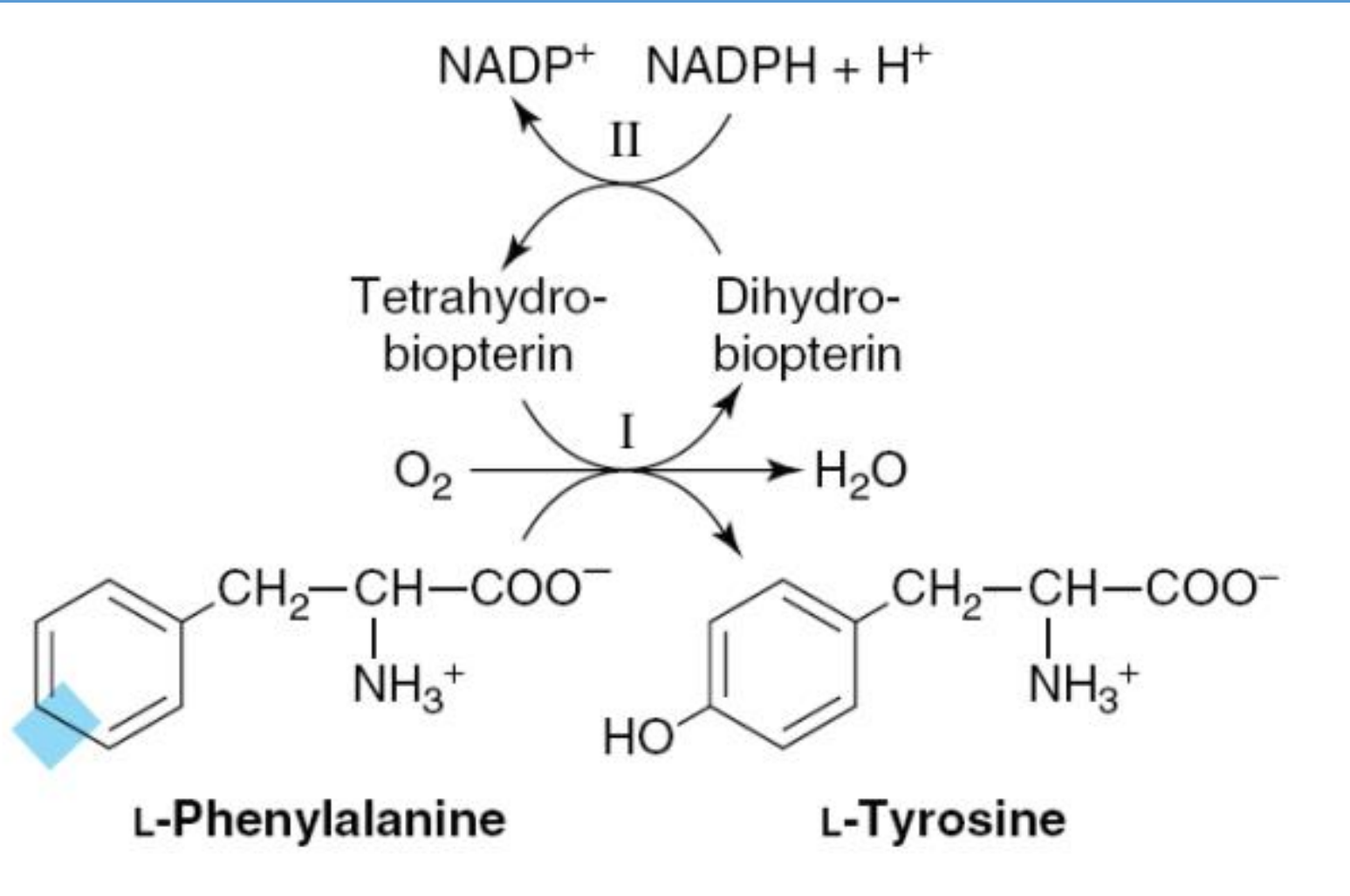


aspartate   α-ketoglutarate   oxaloacetate   glutamate  
**Aminotransferase (Transaminase)**

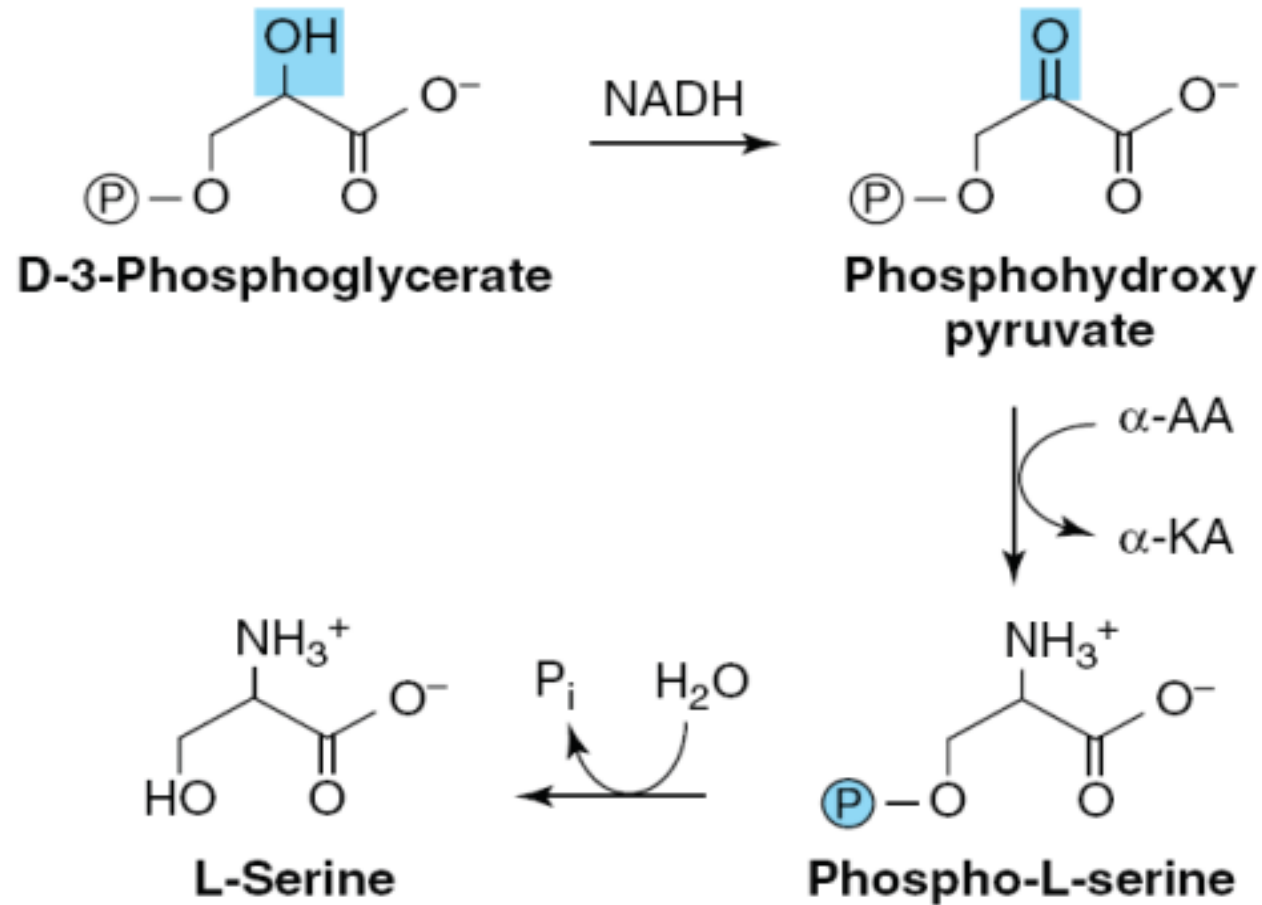


**Figure 28-4.** The asparagine synthetase reaction. Note similarities to and differences from the glutamine synthetase reaction (Figure 28-2).

# بیوسنتز آمینواسیدها: (تیروزین)



# بیوسنتز آمینواسیدها: (سرین)



**Figure 28-5.** Serine biosynthesis. ( $\alpha$ -AA,  $\alpha$ -amino acids;  $\alpha$ -KA,  $\alpha$ -keto acids.)



