



ENZYMES (3)

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Topic discussed in this lecture

Enzyme classification (structure)

- **Simple:** Work without coenzymes

- **Complex :** Need coenzyme (cofactor) to work
- If bound to coenzyme then called "**holoenzyme**" if not, then called "**apoenzyme**"

Naming of enzymes

- 1) **substrate+reaction+ase**
e.g. **ATP synthase**
(most common)
- 2) **product+reaction+ase**
e.g. **Citrate synthase**
(less common)
- 3) inherently named that don't give much info about function
e.g. pepsin, chymotrypsin

EC numbering: numbers specify enzyme-catalyzed reaction (not enzymes) formed of 4 digits
EC a.b.c.d
a) Major class (1-7)
b) Minor class
c) subclass
d) further sub-classification.

Enzyme classification (Function)

1) **Oxidoreductase:** transfer of hydrogen atoms, electrons or oxygen

2) **transferase:** transfer a functional group from one substrate to an acceptor molecule.

3) **Hydrolysis:** These enzymes catalyze cleavage reactions

4) **Lyase:** addition of a molecule to a double bond or reverse.

5) **Isomerase:** same substrate differ in arrangement of atoms

6) **Ligase:** join two substrates

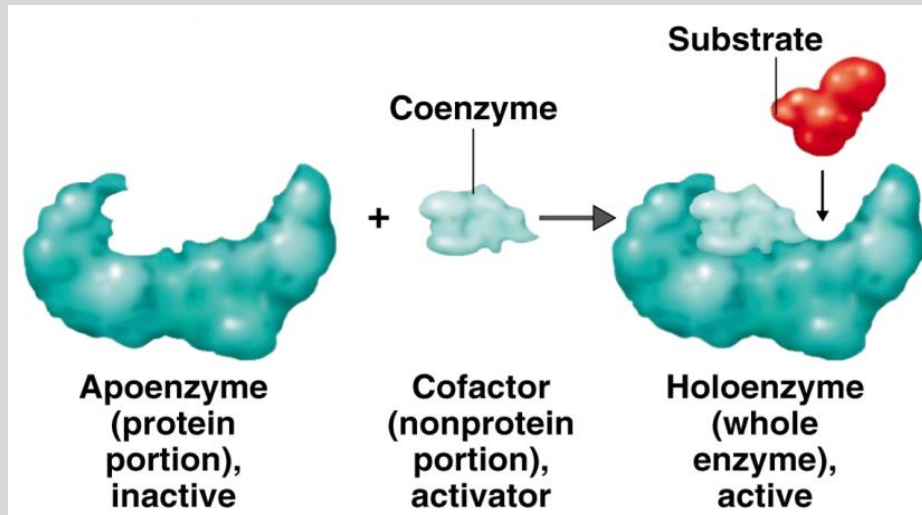
7) **Translocases:** Catalyze the movement of ions or molecules across membranes or their separation within membranes

Enzyme classification (structure)

- **Simple:** simple enzyme can do its action through the amino acids sequence alone

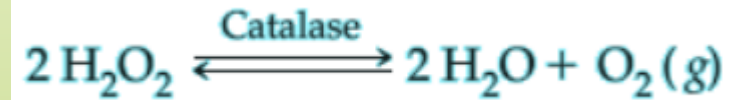
Coenzymes: molecules that bind to active site and assist the catalysis of the reaction

e.g. trypsin, pepsin



- **Conjugated:** need coenzyme or a cofactor (Metal or non- protein chemical compound)

e.g. catalase needs heme group



- **Holoenzyme:** (enzyme with coenzyme)

- **apoenzyme:** (enzyme without having coenzyme) regardless the substrate being there or not.

Naming of enzymes

1) **substrate+reaction+ase**
e.g. **ATP synthase**
(most common)

2) **product+reaction+ase**
e.g. **Citrate synthase**
(less common)

Note: most enzymes end
with "ase"

3) inherently named that
don't give much info
about function
e.g. pepsin, chymotrypsin

EC numbering: numbers specify enzyme-catalyzed reaction (not enzymes).

formed of 4 digits EC a.b.c.d

a) Major class (1-7)

b) Minor class

c) subclass

d) further sub-classification.

e.g. tripeptide aminopeptidases "EC 3.4.11.4"

EC 3: hydrolases

EC 3.4: hydrolases that act on peptide bonds

EC 3.4.11: hydrolases that cleave off the amino-terminal of the amino acid polypeptide

EC 3.4.11.4: cleave off the amino-terminal end from a tripeptide

Enzyme classification (function)

- **1) Oxidoreductase:** transfer of hydrogen atoms, electrons or oxygen (conjugated enzymes)
- Oxidation: gain of oxygen, or loss of electrons, or increasing in oxidation number, or loss of hydrogen
- Reduction: loss of oxygen, or gaining of electrons, or decreasing in oxidation number, or gaining of hydrogen
- Oxidation and reduction occur with each other



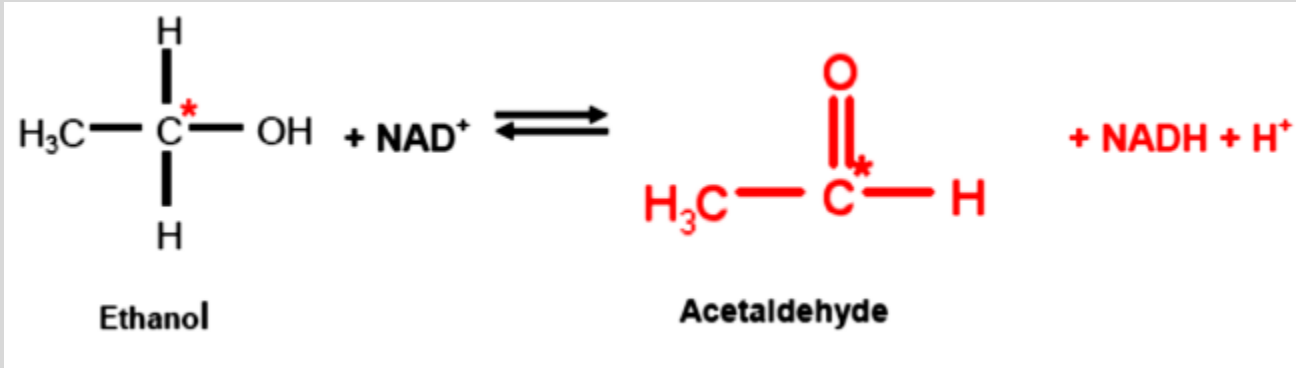
- This group can be further divided into 4 minor classes:
Dehydrogenase, oxidase, peroxidase, oxygenase

Enzyme classification (function)

- 1st) Dehydrogenase: hydrogen transfer from the substrate to an electron recipient (mostly NAD⁺)

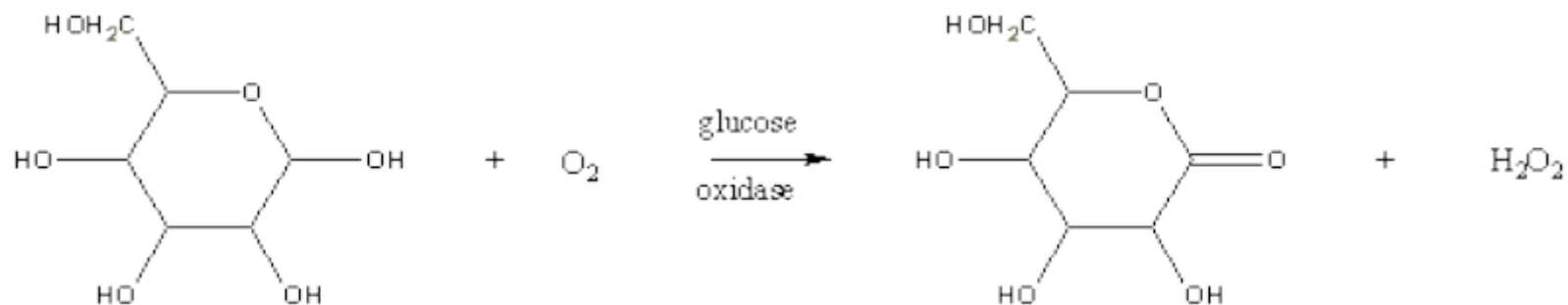
e.g.1. lactate dehydrogenase

e.g.2 Alcohol dehydrogenase



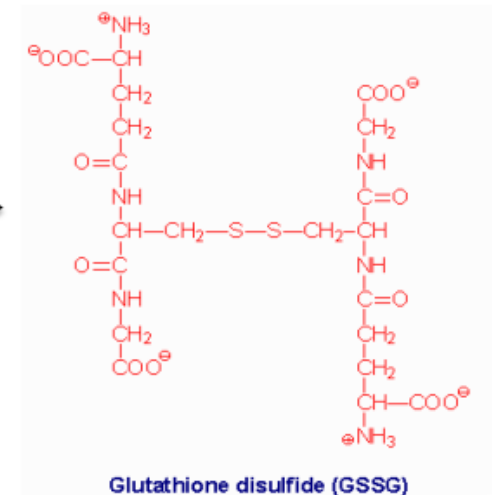
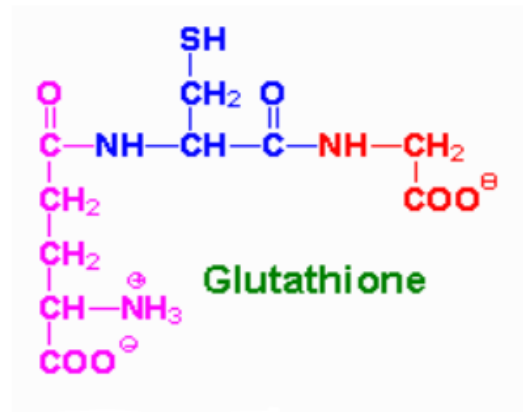
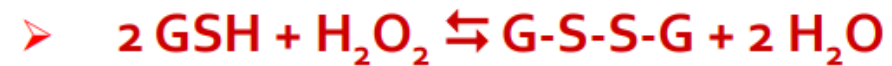
Enzyme classification (function)

- 2nd) Oxidase : transfer hydrogen from the substrate to molecular oxygen producing H₂O₂
- E.g. Glucose oxidase



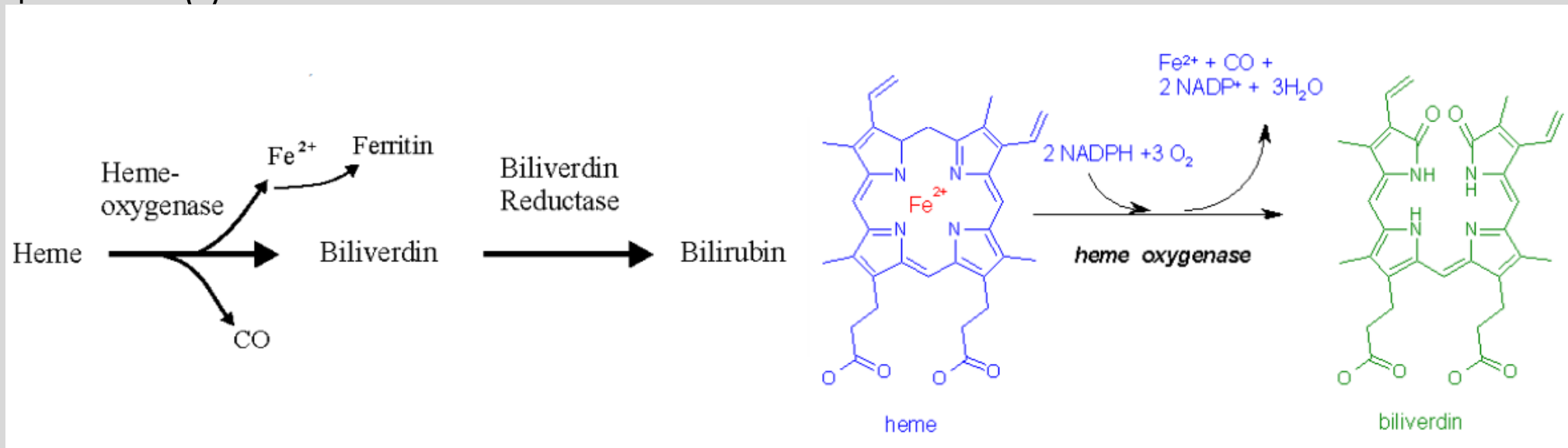
Enzyme classification (function)

- 3rd) peroxidase : catalyze oxidation of a substrate by hydrogen peroxide.
- E.g. Oxidation of two molecules of glutathione (GSH) in the presence of hydrogen peroxide



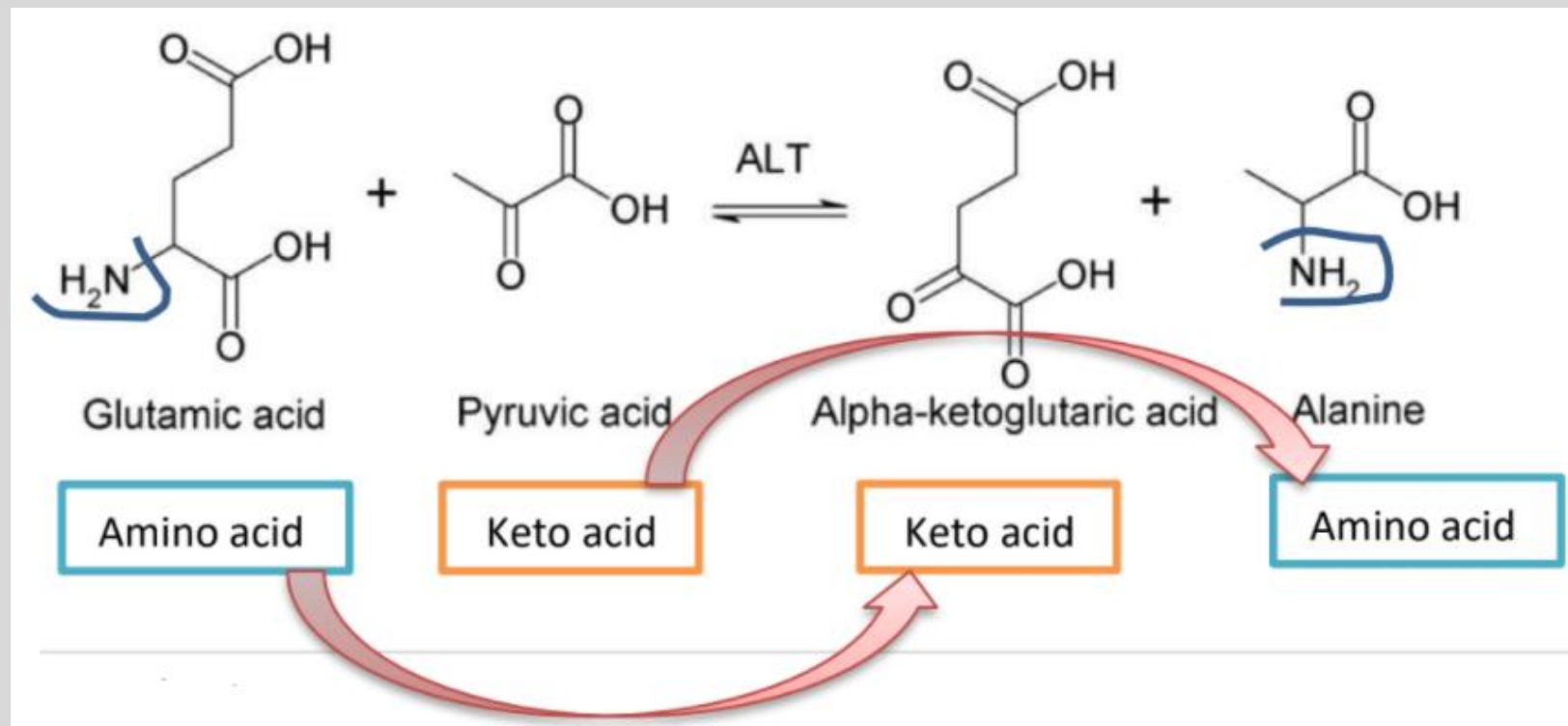
Enzyme classification (function)

- 4th) oxygenase : catalyze substrate oxidation by molecular O₂.
- E.g. The reduced product of the reaction in this case is water not H₂O₂
- There are two types of oxygenase:
Monooxygenases: transfer one oxygen atom to the substrate, and reduce the other oxygen atom to water
Dioxygenases: incorporate both atoms of molecular oxygen (O₂) into the product(s) of the reaction



Enzyme classification (function)

- 2nd) transaminase OR aminotransferases: transfers an amino functional group from one amino acid to a keto acid converting the amino acid to a keto acid and the keto acid to an amino acid



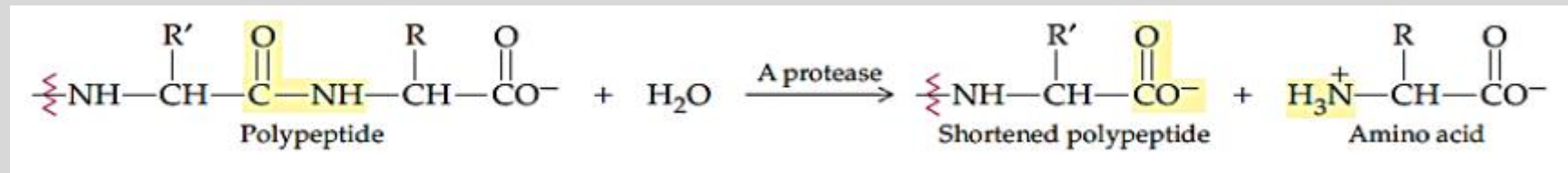
Amino acids	Their corresponding keto acids
alanine	pyruvate
Glutamic acid	Alpha ketoglutaric acid OR Alpha keto glutarate
Aspartic acid Aspartate (4 C)	Oxaloacetate

Enzyme classification (function)

- **3) Hydrolase** : addition of water for cleavage reactions (for all macromolecules)



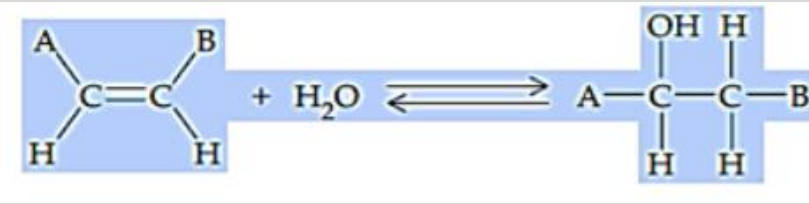
- This group can be further divided into many minor classes: Peptidases (minor class 4), esterases, lipases, glycosidases, phosphatases are all examples of hydrolases named depending on the type of bond cleaved



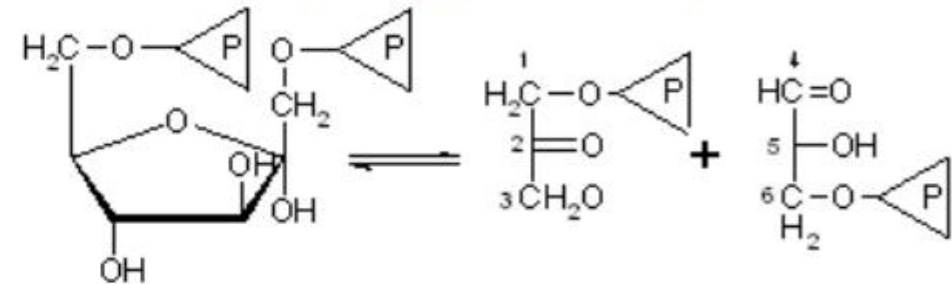
- Note: anything was formed by a condensation reaction can go through hydrolysis reaction
- Trypsin, is quite specific; catalyzes the splitting of peptide bonds only on the carboxyl side of lysine and arginine
- Thrombin, catalyzes the hydrolysis of Arg-Gly bonds in particular peptide sequences only

Enzyme classification (function)

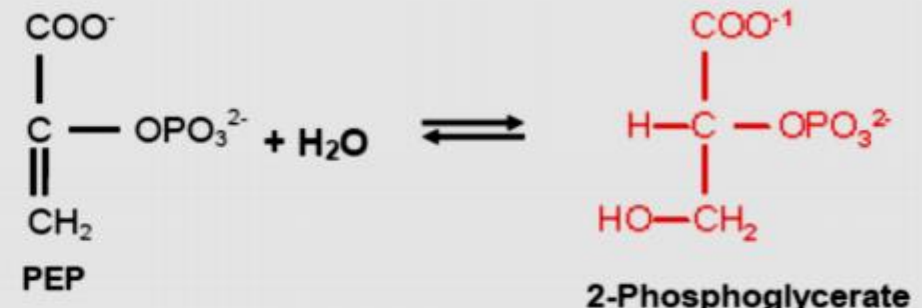
- **4) Lyases:** addition of a molecule (H₂O, CO₂, NH₃) to a double bond between C-C, C-O and C-N or reverse (non-hydrolytic)



- **Aldolase;** breaks down fructose-1,6-bisphosphate into dihydroxyacetone phosphate and glyceraldehydes-3-phosphate



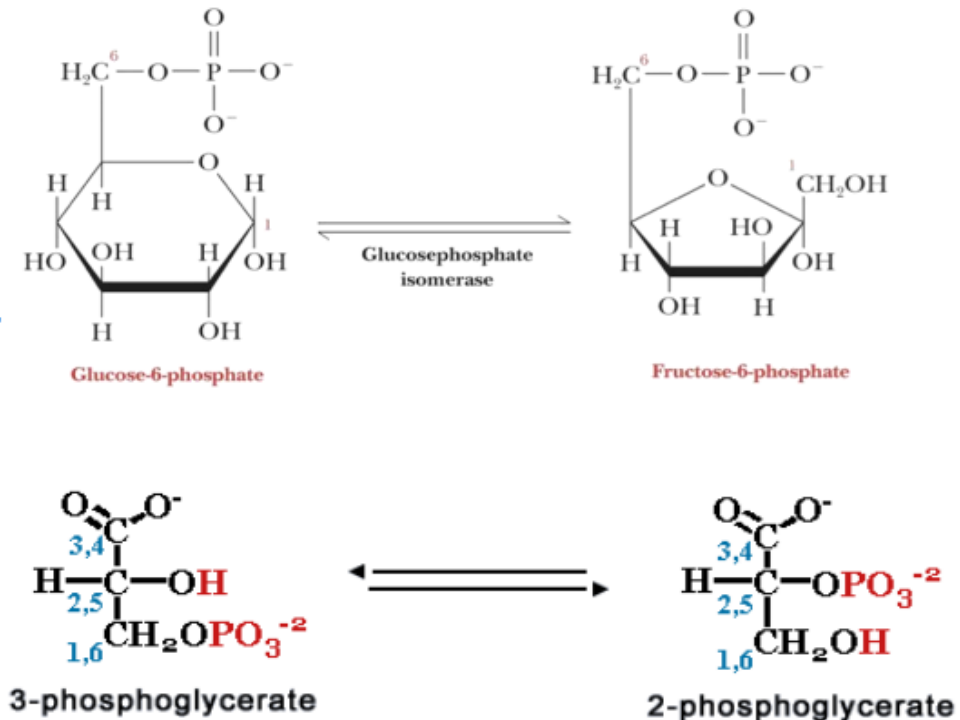
- **Enolase;** interconverts phosphoenolpyruvate and 2-phosphoglycerate by formation and removal of double bonds



Enzyme classification (function)

- **5) isomerase:** catalyze intramolecular rearrangement, there is 1 substrate and 1 product only (mutase is a common minor class)

- **Glucose-6-phosphate isomerase;** isomerizes glucose-6-phosphate to fructose-6-phosphate
- **Phosphoglycerate mutase;** transfers a phosphate group from carbon number 3 to carbon number 2 of phosphorylated glycerate (BPG intermediate)
- **3-P glycerate** \rightleftharpoons **2 P glycerate**

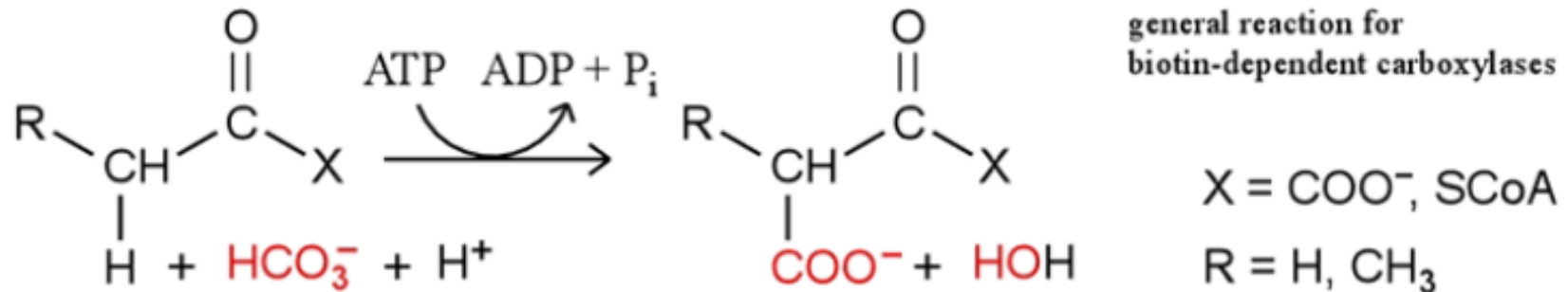


Enzyme classification (function)

- **6)Ligase:** join C-C, C-O, C-N, C-S and C-halogen bonds (need energy)

➤ Pyruvate carboxylase

➤ **Pyruvate + HCO_3^- + ATP \rightleftharpoons Oxaloacetate + ADP + Pi**



Enzyme classification (function)

- **7) Translocase:** catalyze the movement of ions or molecules across membranes or their separation within membranes

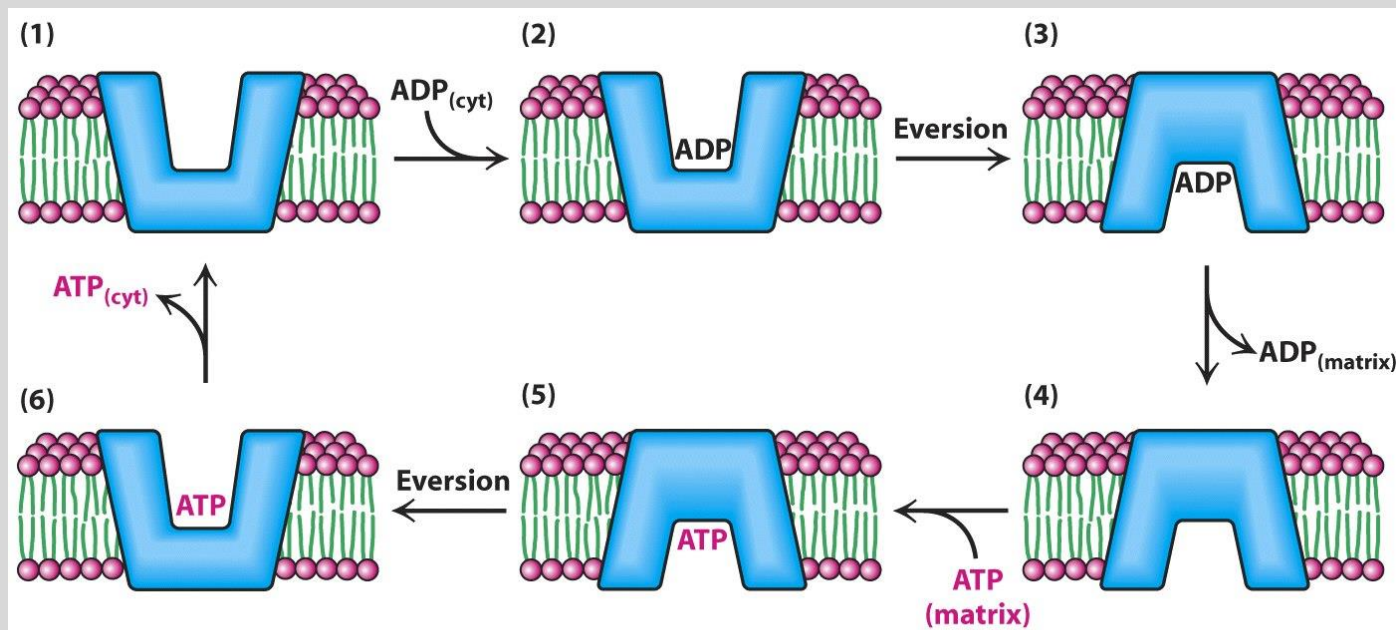


Figure 18-37
Biochemistry, Sixth Edition
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Enzyme classification (Function)

1) **Oxidoreductase:** transfer of hydrogen atoms, electrons or oxygen (need coenzyme)
-4 minor classes:
a- Dehydrogenase: transfer hydrogen from substrate to NAD⁺ usually
b- Oxidase: transfer hydrogen from the substrate to molecular oxygen producing H₂O₂
c- Peroxidase: catalyze oxidation of a substrate by H₂O₂
d- Oxygenase: catalyze substrate oxidation by molecular O₂, may be monooxygenase or dioxygenase

2) **transferase:** transfer a functional group (C, N, P or S) from one substrate to an acceptor molecule.
- 2 minor classes:
1- kinases (transfer of a phosphate group from one molecule to another. The most common source for phosphate group is (ATP)
2- Transaminase: transfers an amino functional group from one amino acid to a keto acid (it has an acidic part and ketone part), converting the amino acid to a keto acid and the keto acid to an amino acid.

3) **Hydrolase:** These enzymes catalyze cleavage reactions while using water across the bond being broken.

4) **Lyase:** addition of a molecule (H₂O, CO₂, NH₃) to a double bond or reverse (non-hydrolytic).

5) **Isomerase:** one substrate and one product

6) **Ligase:** join C-C, C-O, C-N, C-S and C-halogen bonds

7) **Translocases:** Catalyze the movement of ions or molecules across membranes or their separation within membranes (ATP/ADP translocase)