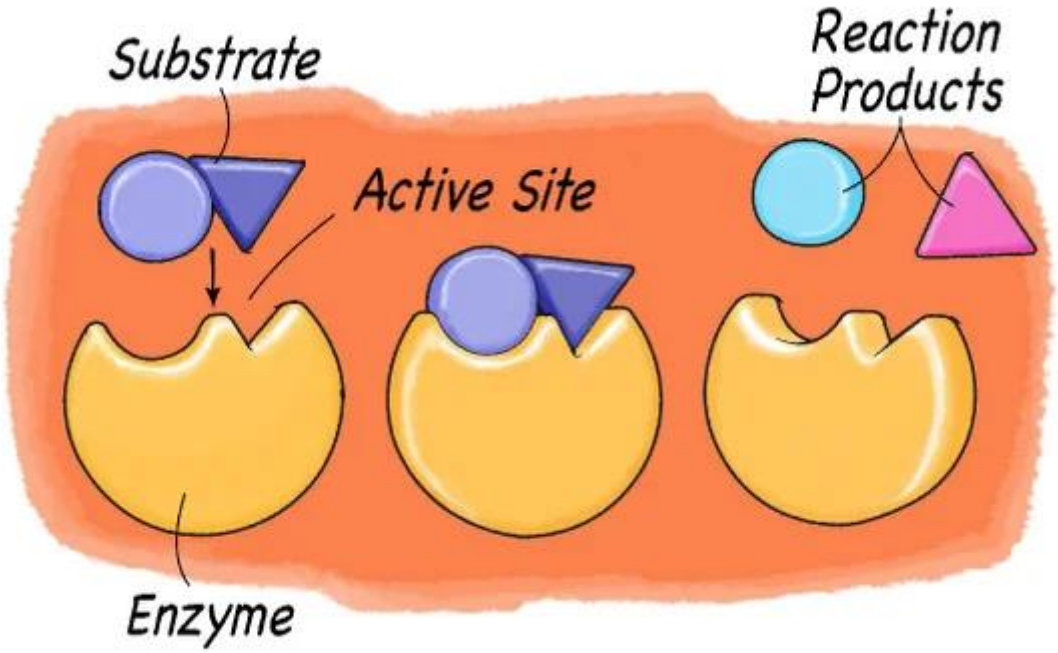
Reaction in cells: Enzyme and coenzyme



Patcharee Boonsiri

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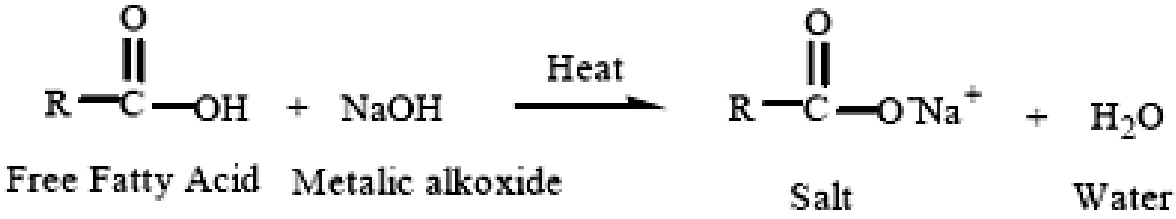
Objectives

1. Enzyme properties, classification, nomenclature, isoenzyme
2. Enzyme kinetics K_m, V_{max}
3. Enzyme inhibition
4. Enzyme regulation
5. Coenzyme: classification, important coenzymes in metabolism

Metabolism involves with many chemical rxs.

Acid – base reaction

Acid + base → salt + H_2O



Esterification reaction

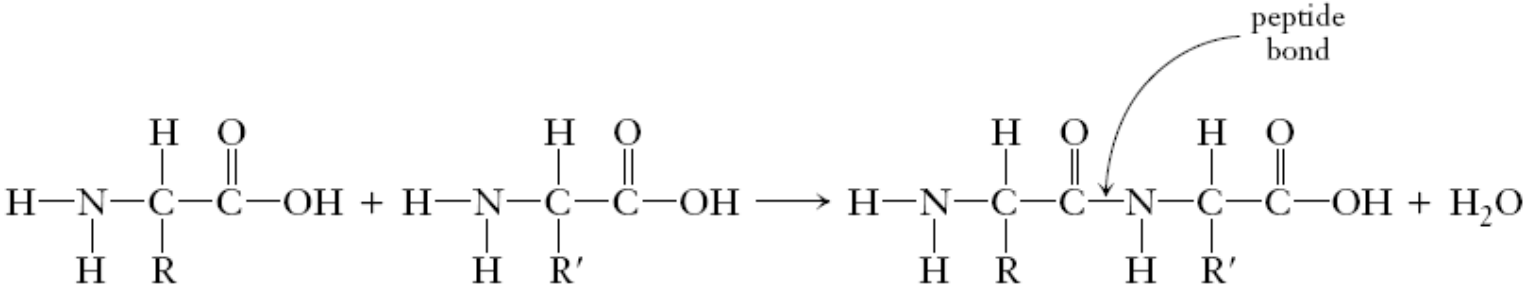
Acid + alcohol → ester + H_2O

Hydrolysis reaction

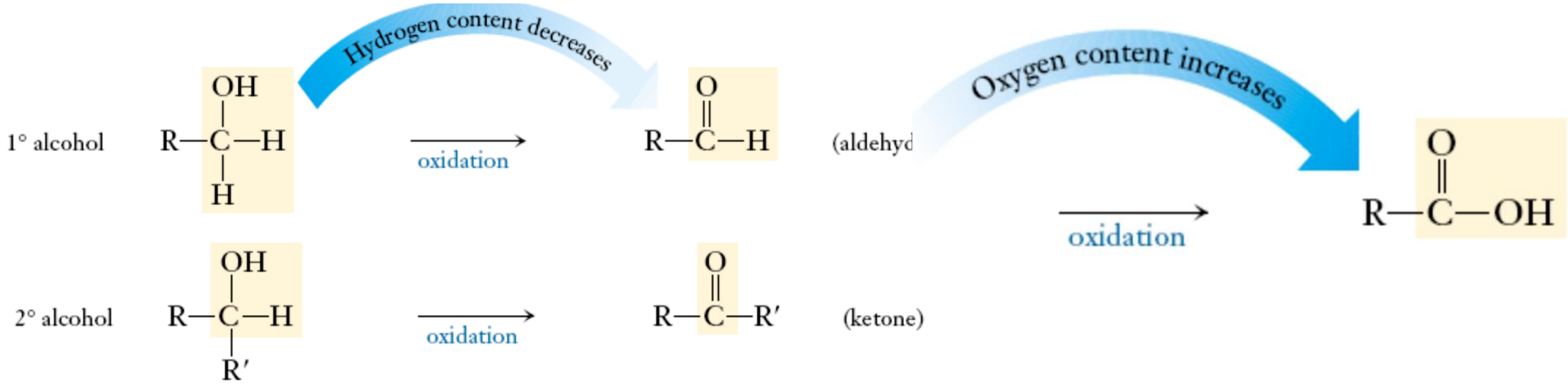
$ATP + H_2O \rightarrow ADP + Pi$

Polymerization reaction

Monomer + monomer + …. → polymer



Oxidation- reduction (redox) reaction

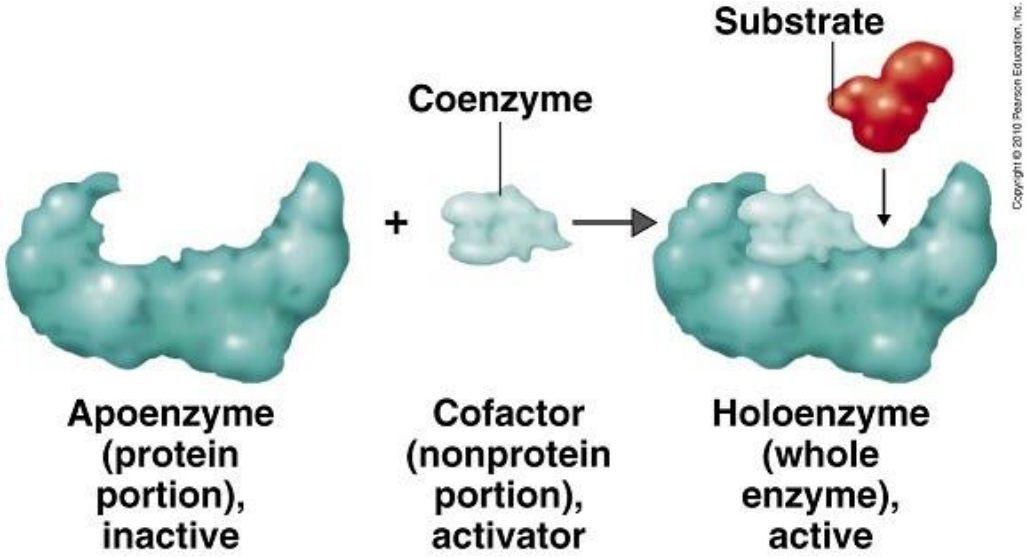


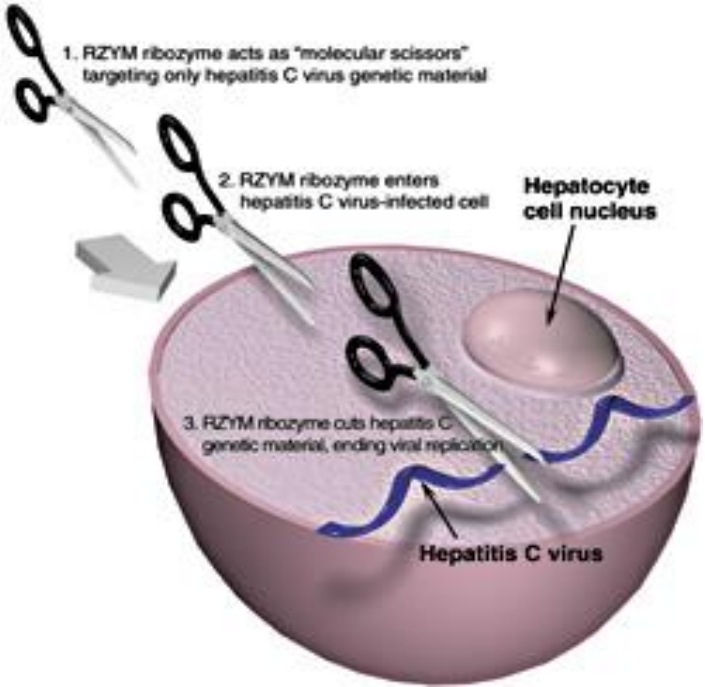
Enzyme is a biological catalyst

Enzymes are

- **Proteins**
- **Nucleic acid e.g.**

Ribozymes (cut RNA)





Ribozymes remove pieces of intron (nonfunctional mRNA) and splice the exon (functional portions)

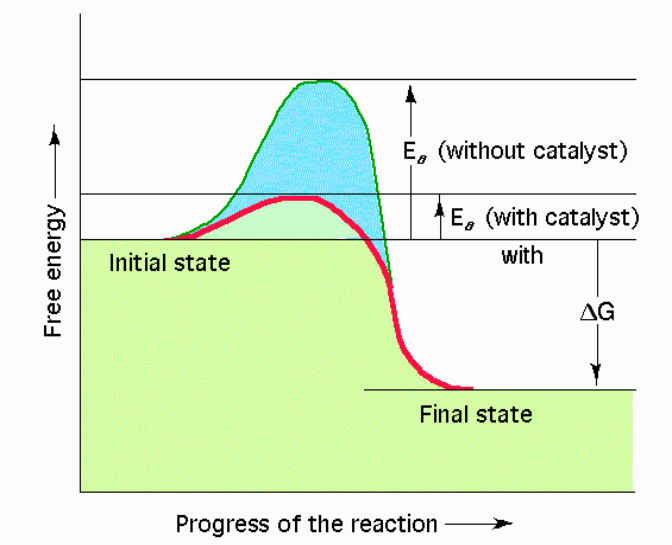
Enzyme properties

1.accelerate chemical rxs

2.mild condition

3.substrate specificity

4.regulatory



www.agen.ufl.edu/.../lect/lect_03/lect_03.htm

Enzyme cannot change K_{eq}

$$A + B \rightleftharpoons C + D$$

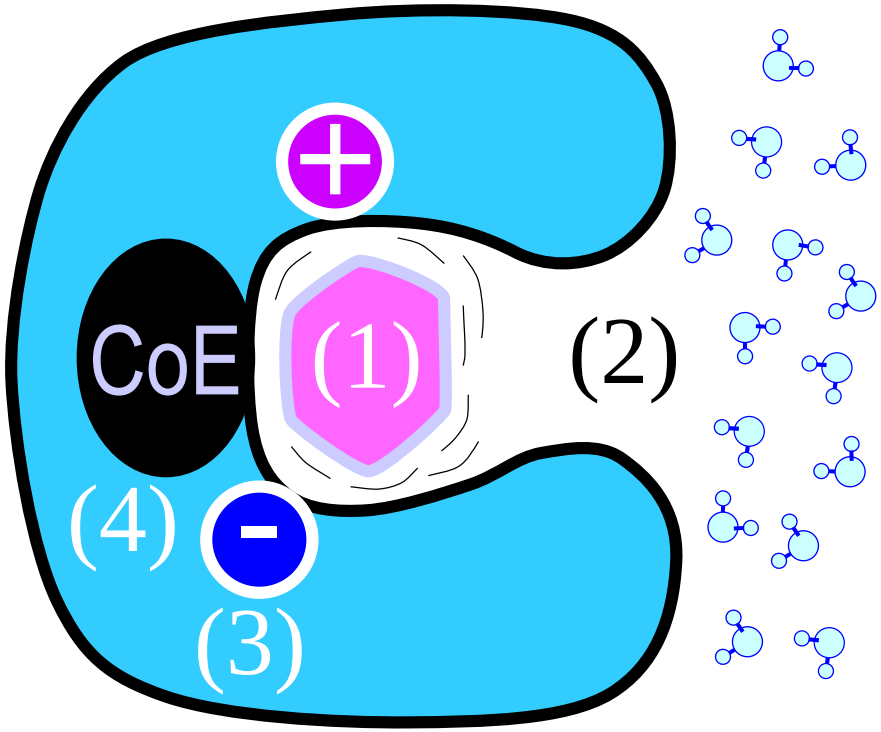
$$Keq = \frac{[C][D]}{[A][B]}$$

Rx go to equilibrium faster

Enzyme accelerate chemical rx. by decreasing E_a , but not ΔG

Enzyme has active site

active site is the site for catalyzing rx



It is a magic pocket

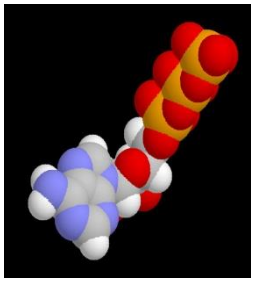
(1) Stabilizes transition

(2) Expels water (see Ex.)

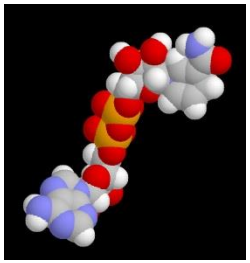
(3) Reactive groups

(4) Coenzyme helps

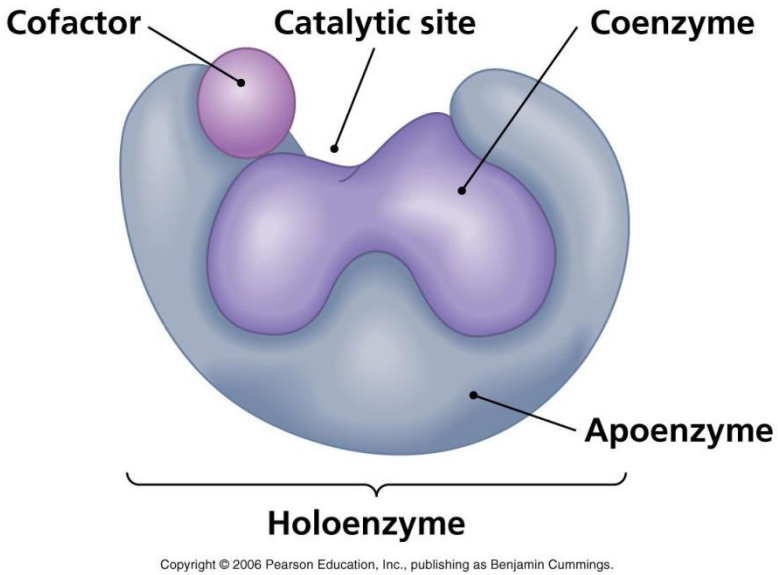
Some enzymes need “help” from coenzymes, cofactors

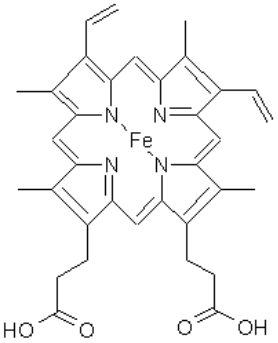


ATP

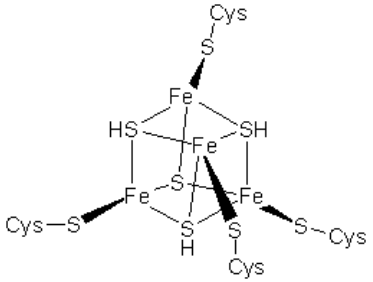


NADH





Fe^{2+} tightly bound to heme (hemoglobin, cytochrome)



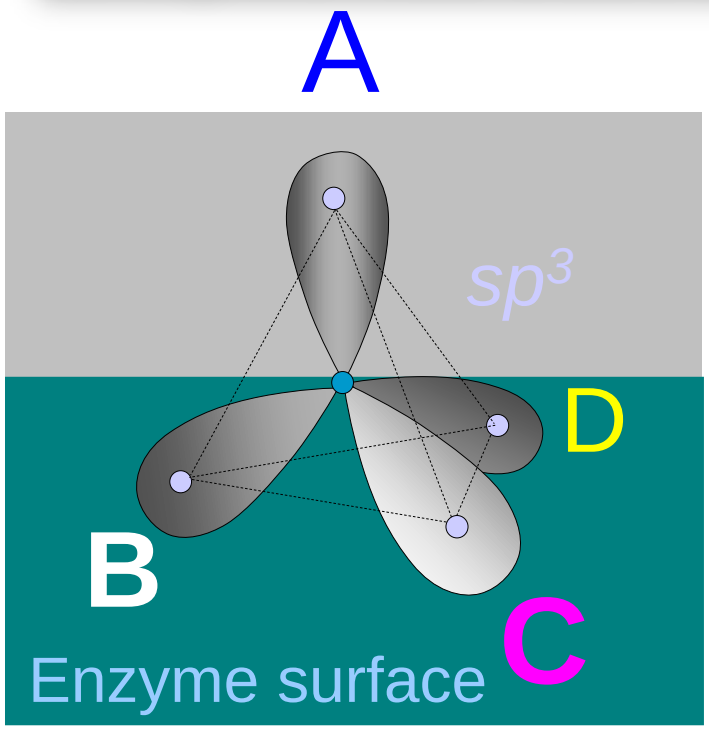
Iron-sulfur cluster (ferridoxin) found in photosynthesis

Coenzyme e.g. ATP, NADH

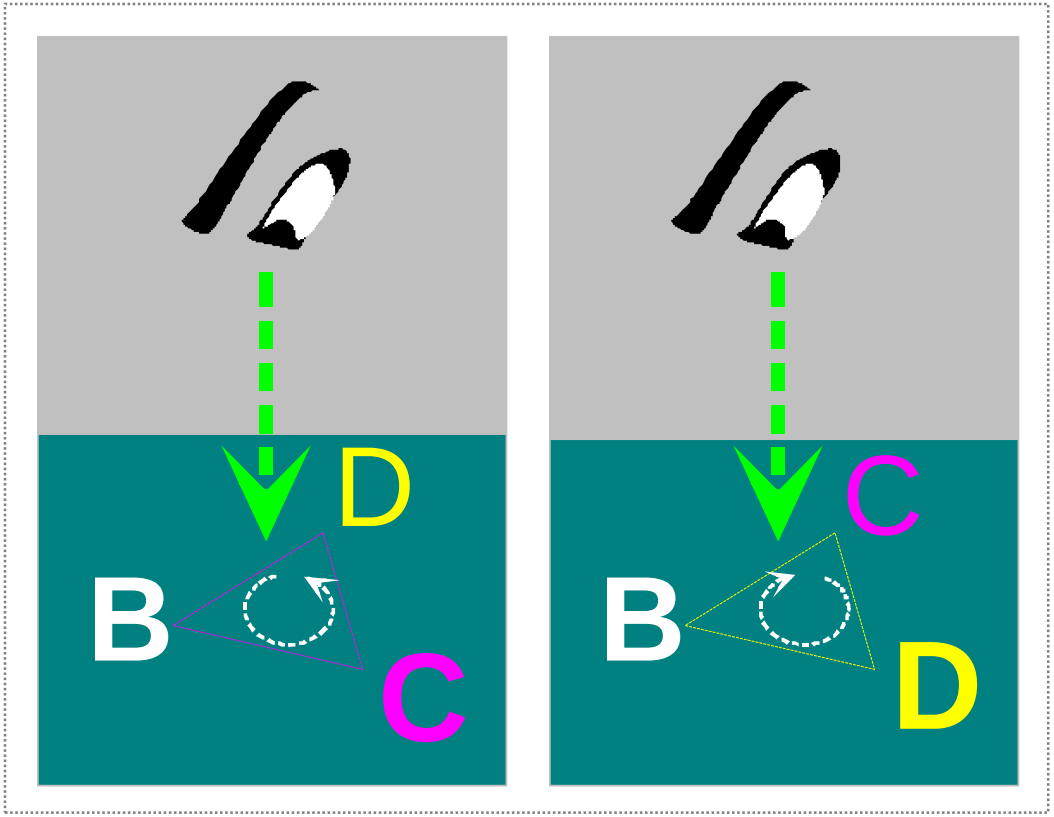
Cofactor e.g. metal ions Fe^{2+}, Mg^{2+}

Prosthetic group e.g. Fe^{2+} in heme

Enzyme has substrate specificity (stereo specificity)



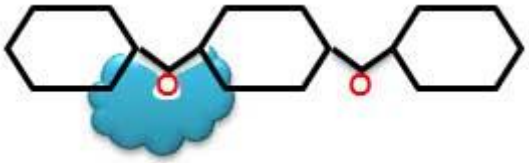
The tetrahedral structure of carbon orbital has rigid steric strain which makes the basic building unit of protein conformation



These two triangles are not identical

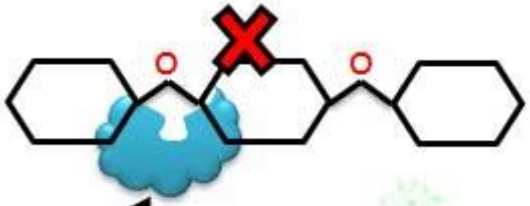
Stereo specificity of Enzymes

α-1-4 Linked Glucose (Starch)



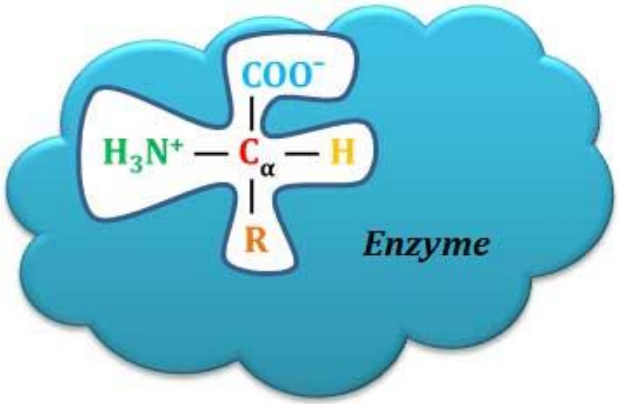
α-Amylase

β-1-4 Linked Glucose (Cellulose)

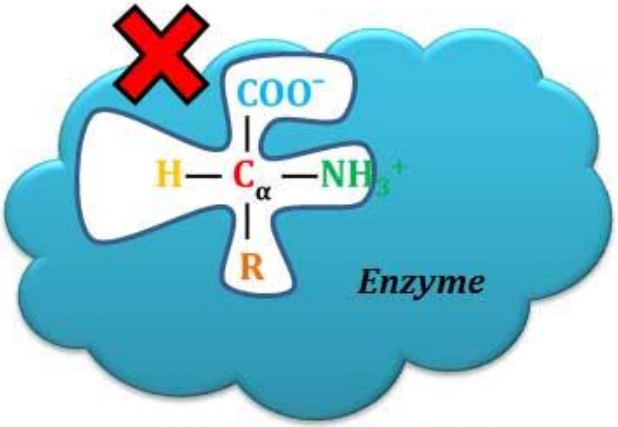


α-Amylase

Stereo specificity of Enzymes



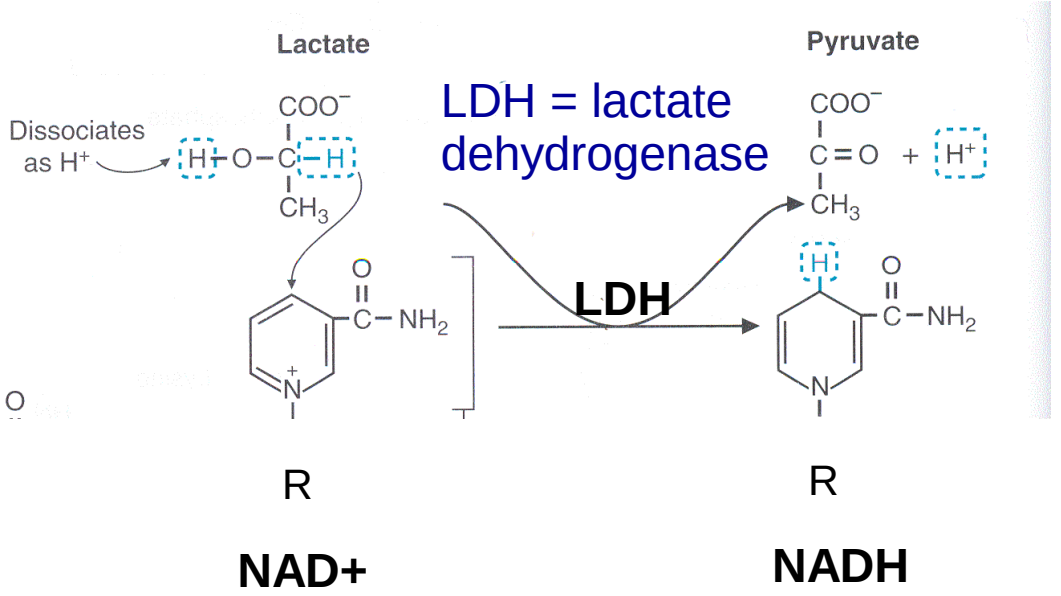
L-Alanine Oxidase & L-Alanine



L-Alanine Oxidase & D-Alanine

Enzyme classification

CLASS	DESIGNATION	FUNCTION
EC1	Oxidoreductases	catalyze oxidation/reduction reactions
EC2	Transferases	transfer a functional group (e.g. a methyl or phosphate group)
EC3	Hydrolases	catalyze the hydrolysis of various bonds
EC4	Lyases	cleave various bonds by means other than hydrolysis and oxidation
EC5	Isomerases	catalyze isomerization changes within a single molecule
EC6	Ligases	join two molecules covalent bonds.



1.Oxido-reductases

$$A_{ox} + B_{red} \longrightarrow A_{red} + B_{ox}$$

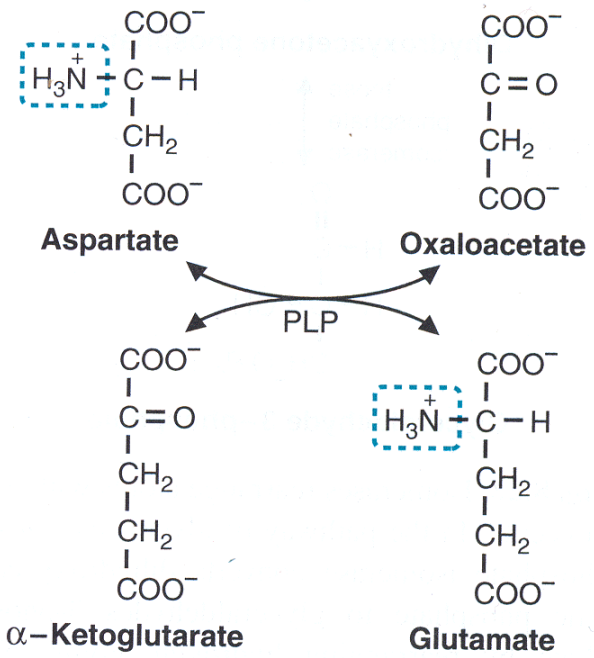
Ex. dehydrogenase, oxidase, reductase , catalase, peroxidase

2.Transferases

transfer of a specific functional group between molecules

AB + CD ⟶ AC + BD

Ex. Kinase (hexokinase, glucokinase),transcarboxylase, transmethylase, transaminase



Aminotransferase reaction in which pyridoxal phosphate (PLP) is used as a cofactor

3.Hydrolases

hydrolytic cleavage of C-O, C-N, C-C

$$AB + H_2O \longrightarrow AOH + BH$$

Ex. esterase, phosphatase, peptidase

very important hydrolases are the proteases (involved in cleaving peptide bonds)

Proteases

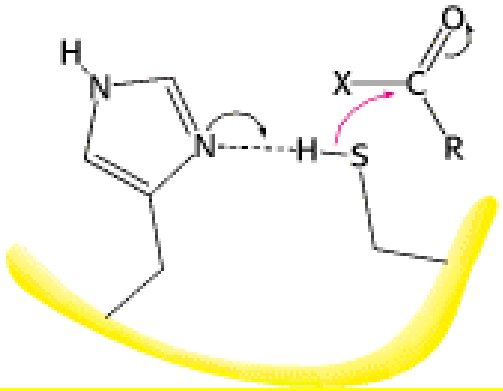
1) Cysteine proteases

2) Aspartyl proteases

3) Metalloproteases

4) Serine proteases

Cysteine Proteases



Caspases are important mediators of apoptosis.

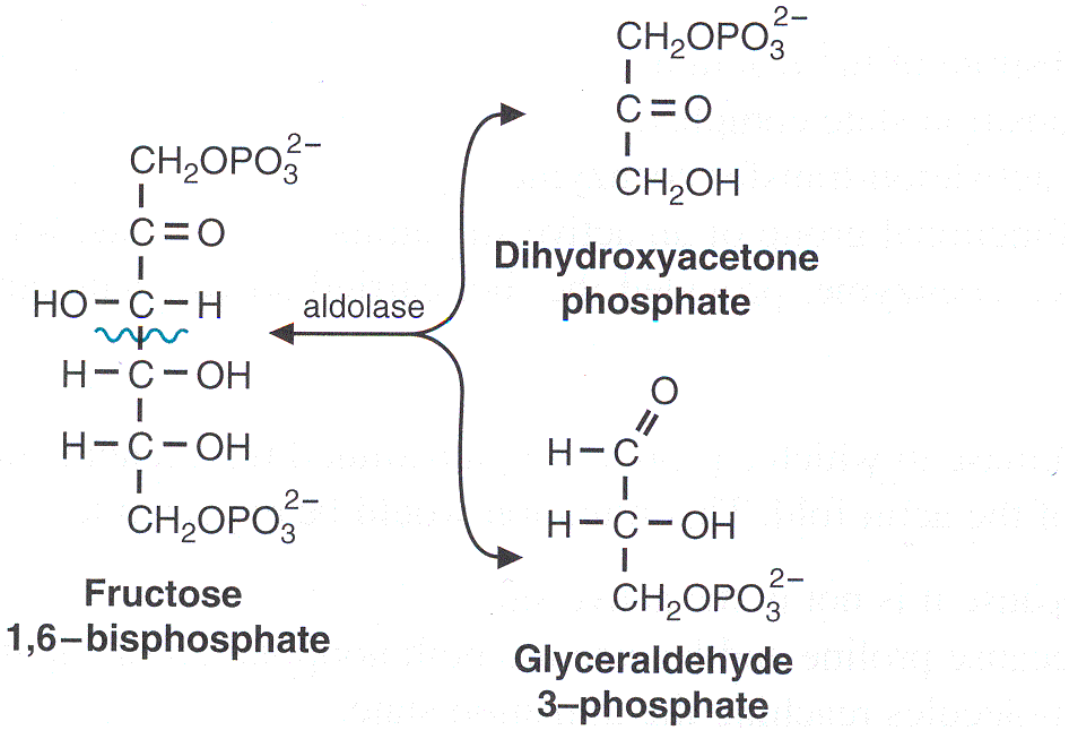
Caspase = Cysteine prote**ases** that cleave peptide bonds next to **asp**artate residues

4.Lyases

cleave C-C, C-O, C-N by **elimination**, leaving double bonds or rings, or conversely adding groups to double bonds

ABC ⟶ AB + C

Ex. **aldolases** (in glycolysis), **thiolases** (in breakdown of fatty acids), decarboxylase, dehydratase, deaminase, synthase



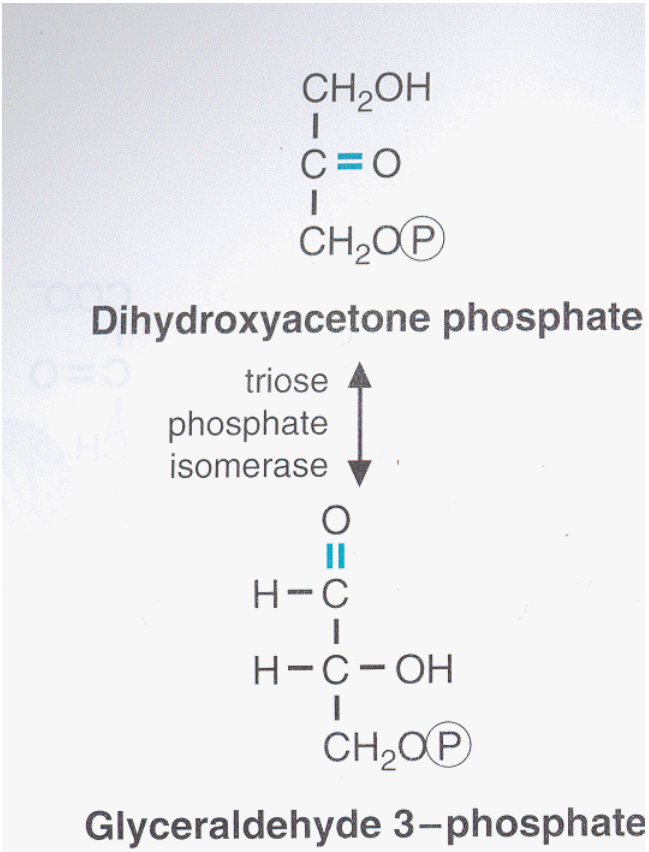
5.Isomerases

intramolecular rearrangements

ABC ⟶ BAC

Ex. epimerase, isomerase, mutase

triose phosphate isomerase catalyzes the interconversion between dihydroxyacetone phosphate and D-glyceraldehyde 3-phosphate (in glycolysis)

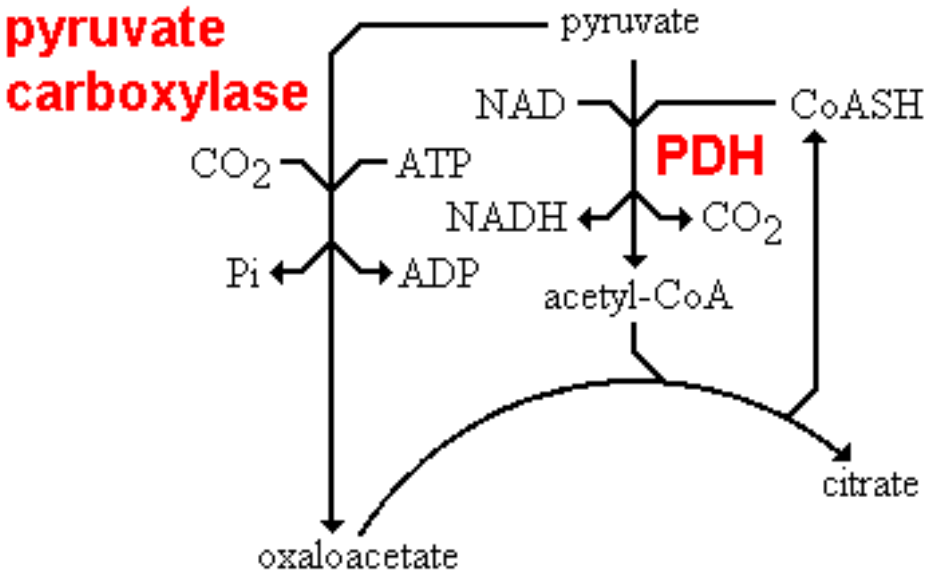


6.Ligases

join together of two molecules coupled with the hydrolysis of a pyrophosphate bond in **ATP**

AB + C + ATP ⟶ ABC + ADP + Pi

Ex. synthetase, carboxylase



Enzyme nomenclature

Trivial name e.g. trypsin, pepsin

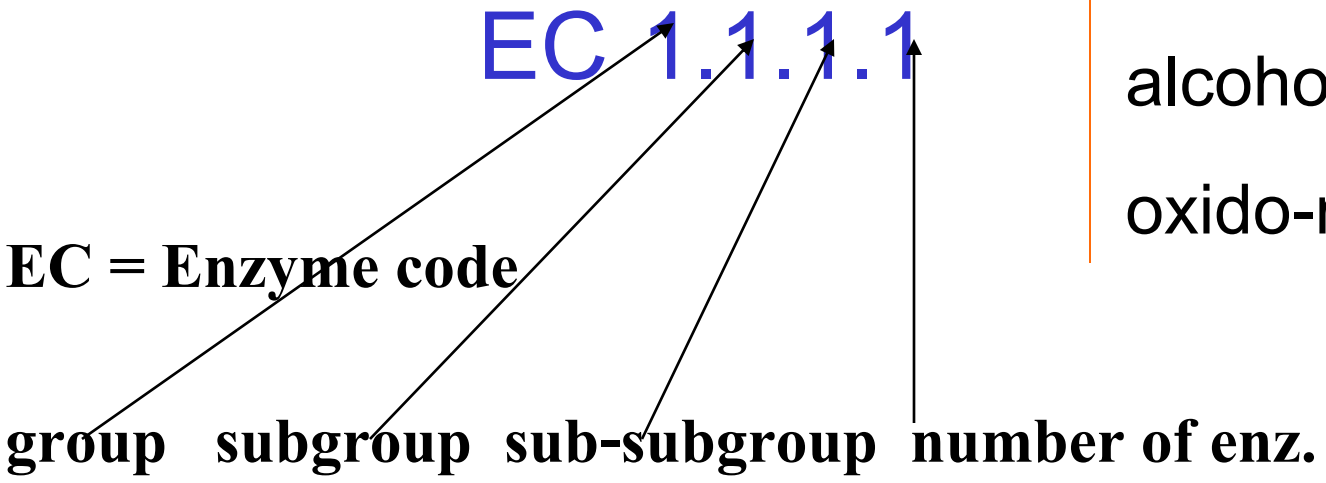
Systematic name

alcohol

dehydrogenase

alcohol:NAD+

oxido-reductase



Isoenzyme

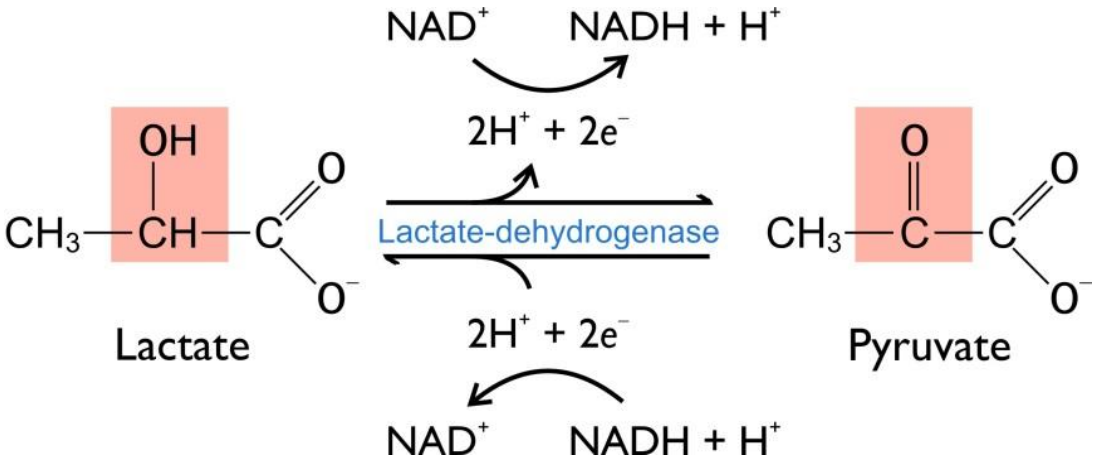
Different - protein, structure, genetic code

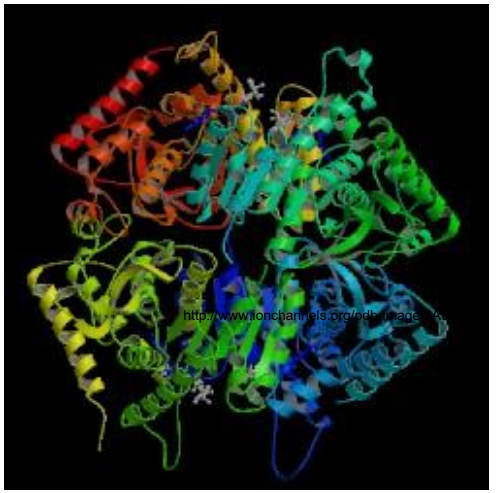
Same – catalyze the same rx.

- Oligomeric forms of more than one type of subunits (e.g. lactate dehydrogenase)
- Different carbohydrate content (e.g. alkaline phosphatase)
- Synthesized from different genes (e.g.malate dehydrogenase in cytoplasm or in mitochondria)

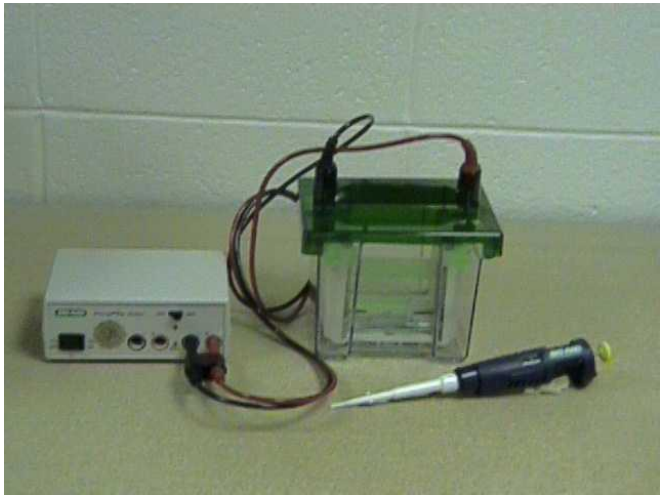
Example of isoenzyme:

LDH (lactate dehydrogenase)



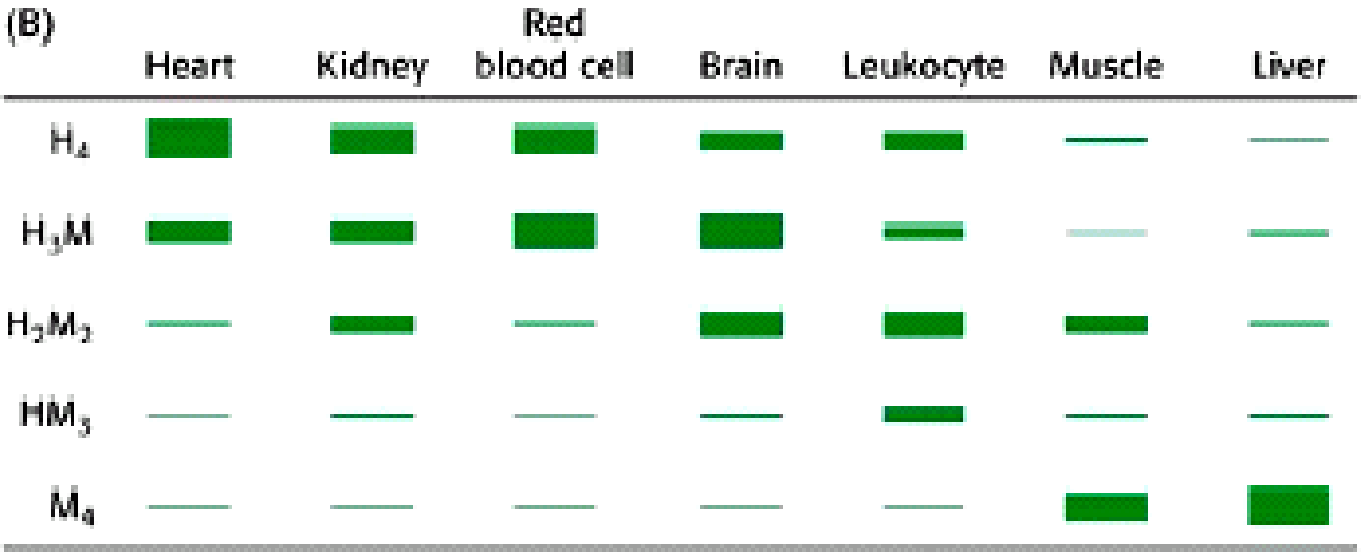


LDH1	HHHH	myocardium
LDH2	HHHM	rbc, myocardium
LDH3	HHMM	brain, kidney
LDH4	HMMM	
LDH5	MMMM	liver, skeletal muscle



http://www.gannon.edu/resource/dept/sim/ELECTROPHORESIS.jpg

Electrophoresis technique – see isoenzymes from different sources



http://www.chem.indiana.edu/academics/ugrad/Courses/c582/documents/Lecture20-Notes.pdf