Enzymes

6.1 An Introduction to Enzymes

6.2 How Enzymes Work

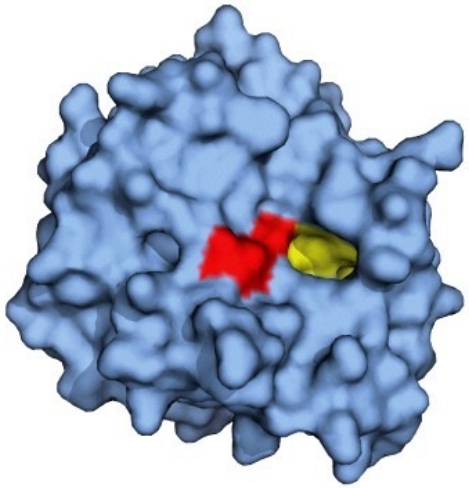
6.3 Enzyme Kinetics

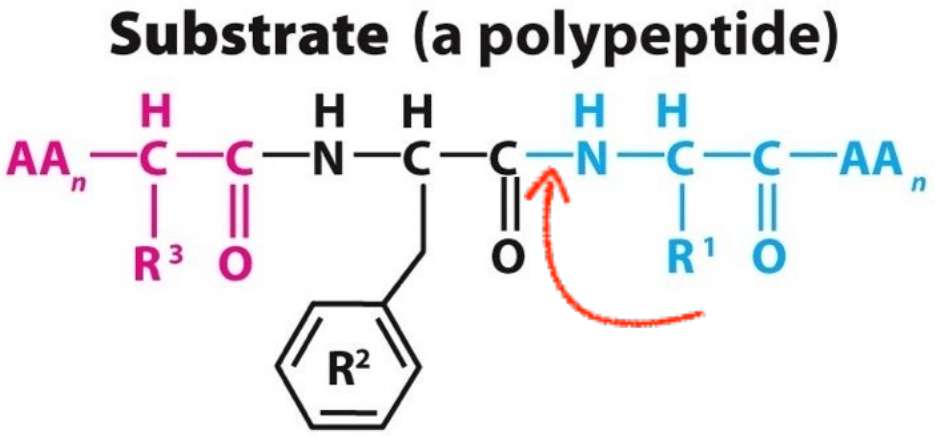
6.4 Examples of Enzymatic Reactions

6.5 Regulatory Enzymes

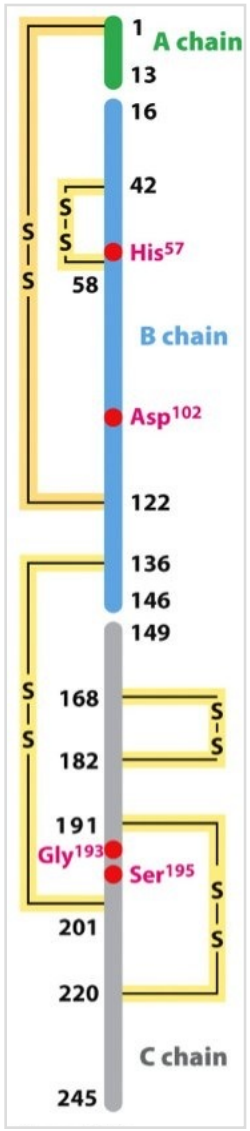
What Is Chymotrypsin?

- Digestive enzyme. Protease.
- Catalyze proteolysis (breakdown of proteins).
- Preferentially cleave peptide bonds after an aromatic amino acid residue (Phe, Tyr and Trp).
  - Aromatic ring fits into a hydrophobic pocket.
  - Hydrophobic and shape complementarity.



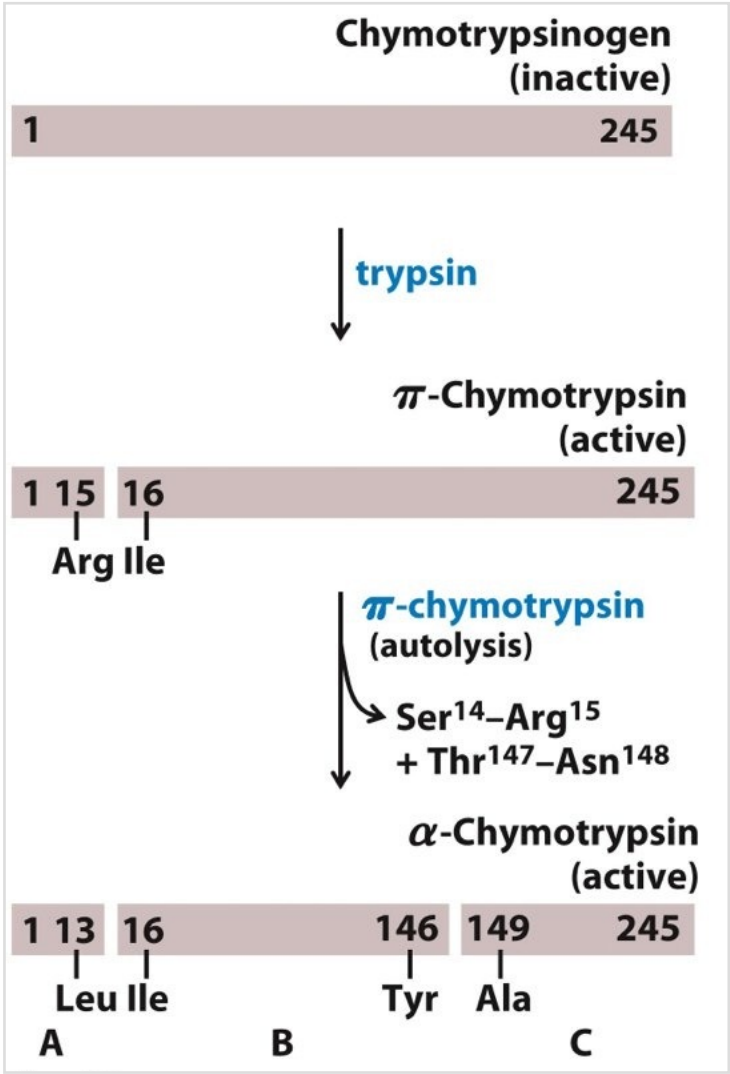


Chymotrypsin Primary Structure

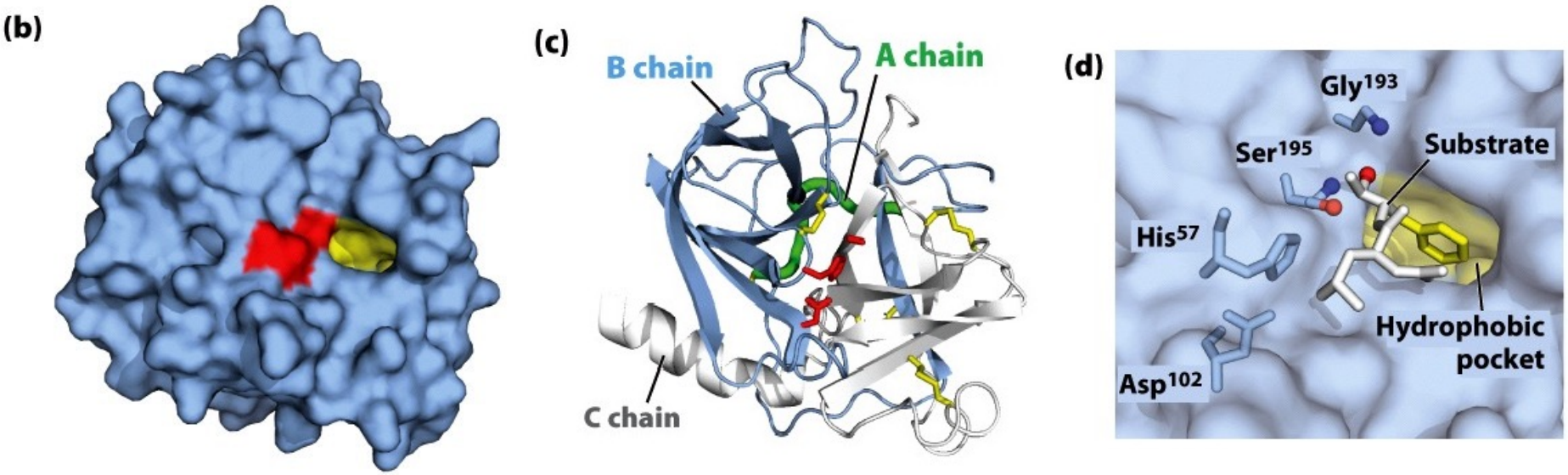


- Three subunits.
- Disulfide bonds.
- Catalytically important residues shown in red.

- Why does numbering of B and C chains not start from 1?
- Why are some residues missing?
- Proenzyme chymotrypsinogen (inactive)



Chymotrypsin Quaternary Structure



Hydrophobic pocket

Key active-site residues

A chain

B chain

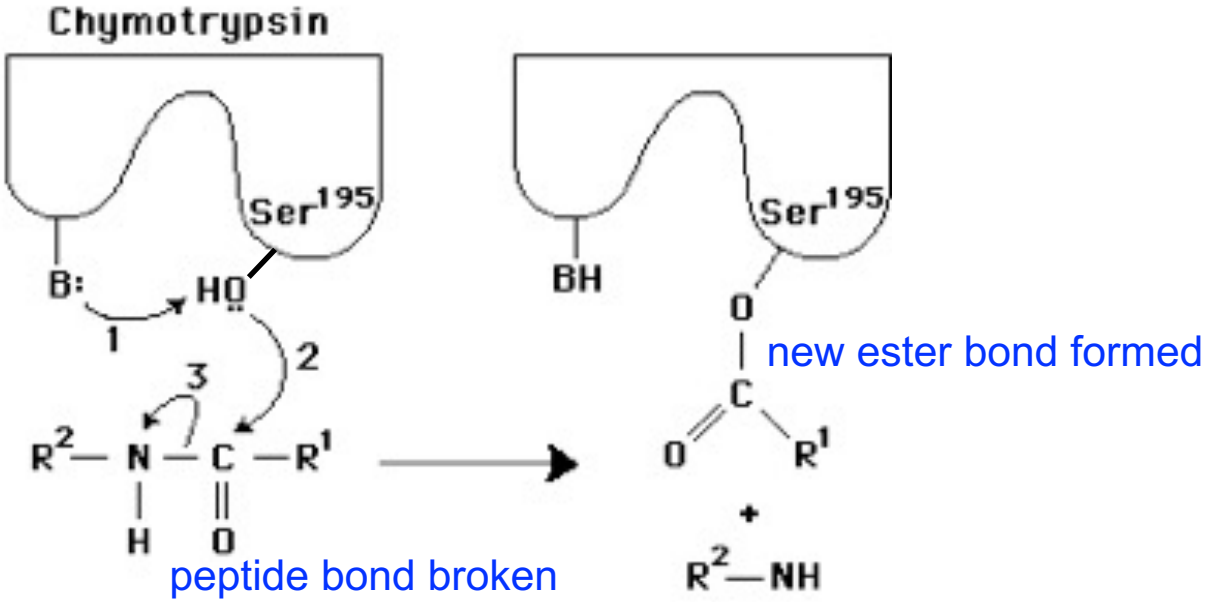
C chain

Disulfide bonds

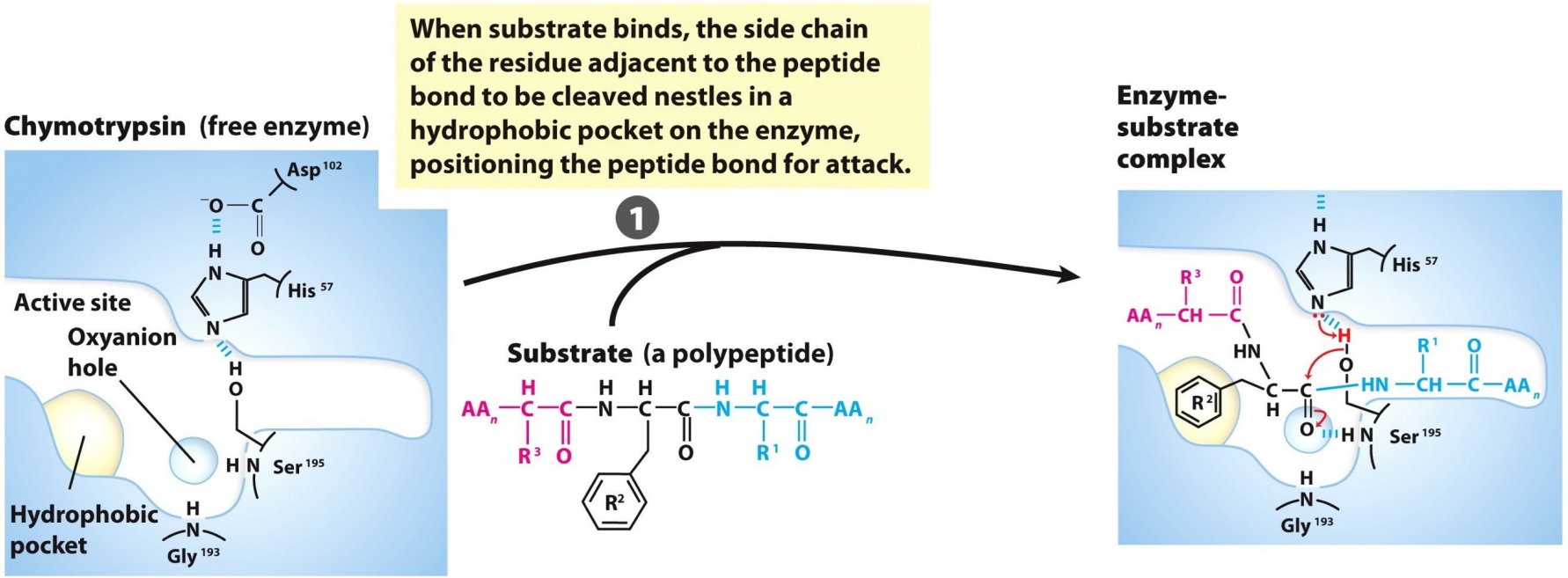
- **Ser as nucleophile**
- **His as base**
- **Asp H-bond**

Chymotrypsin Catalysis Mechanism

- Transition state stabilization.
- **General acid-base catalysis and covalent catalysis.**
  - Transient covalent acyl-enzyme intermediate.
  - Two steps: acylation and deacylation
  - Acylation: peptide bond cleaved and ester bond formed
  - Deacylation: ester bond cleaved and enzyme regenerated

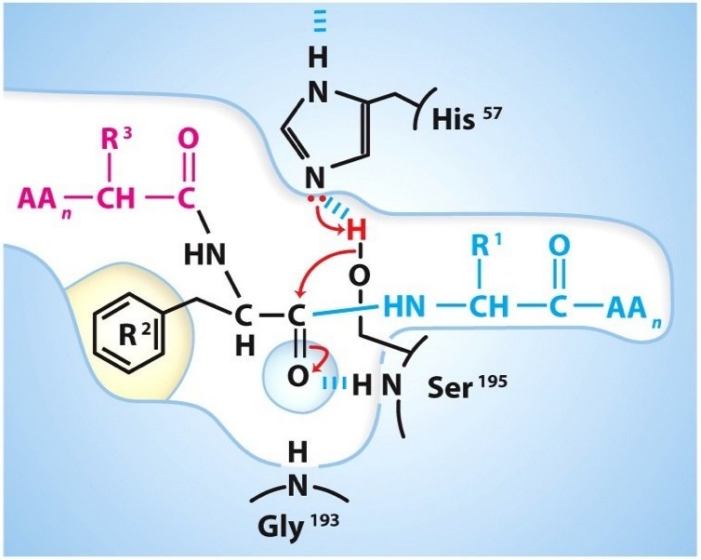


Step 1: Substrate Binding



- H bond between Asp and His
- H bond between His and Ser
- Oxyanion hole stabilized by Ser and Gly
- Hydrophobic pocket for side chain

How to Read Reaction Mechanism



Electron pairs in carbonyl group (C=O) NOT shared equally.

- C relatively electron-deficient
- Nucleophile (electron-rich)
- Electrophile (electron-deficient)

Electron pushing

- A pair of electrons (-$\ddot{O}$H)
- Arrow represent movement

Electronegativity

- F > O > N > C ≈ S > P ≈ H

Nucleophiles	Electrophiles
Negatively charged oxygen (as in an unprotonated hydroxyl group or an ionized carboxylic acid)	Carbon atom of a carbonyl group (the more electronegative oxygen of the carbonyl group pulls electrons away from the carbon)
Negatively charged sulfhydryl	Protonated imine group (activated for nucleophilic attack at the carbon by protonation of the imine)
Carbanion	Phosphorus of a phosphate group
Uncharged amine group	Proton
Imidazole	
Hydroxide ion	

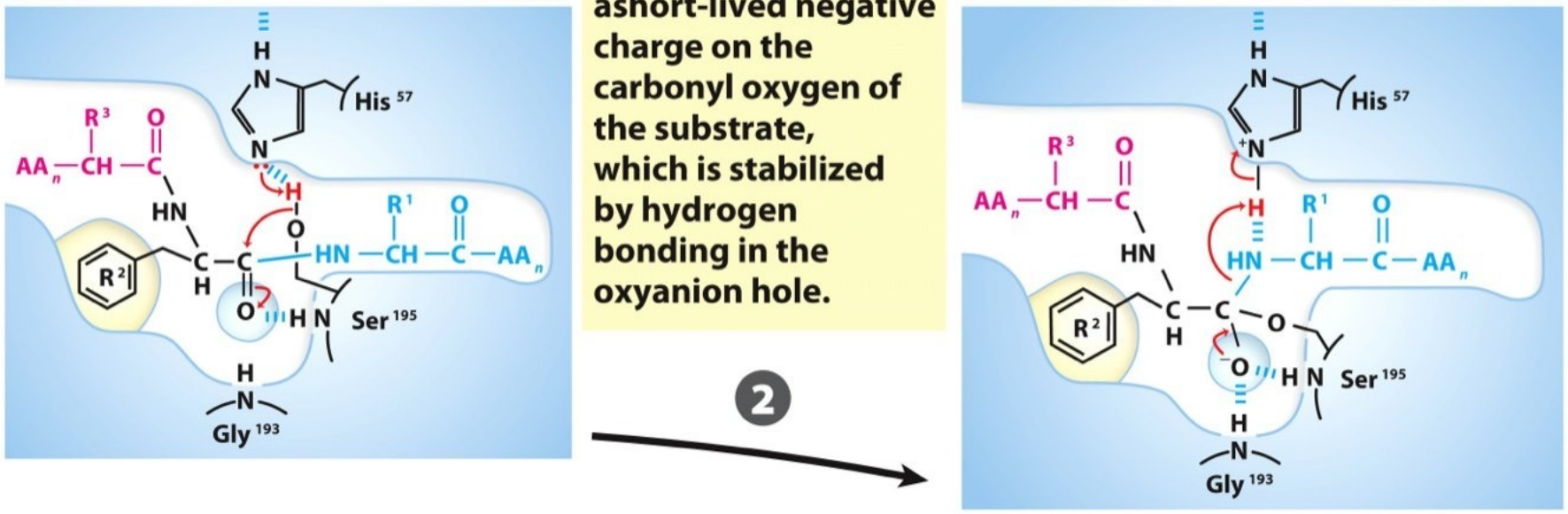
Step 2: Nucleophilic Attack

Alkoxide: RO^-

Enzyme-substrate complex

Interaction of Ser195 and His57 generates a strongly nucleophilic alkoxide ion on Ser195; the ion attacks the peptide carbonyl group, forming a tetrahedral acyl-enzyme. This is accompanied by formation of ashort-lived negative charge on the carbonyl oxygen of the substrate, which is stabilized by hydrogen bonding in the oxyanion hole.

Short-lived intermediate* (acylation)

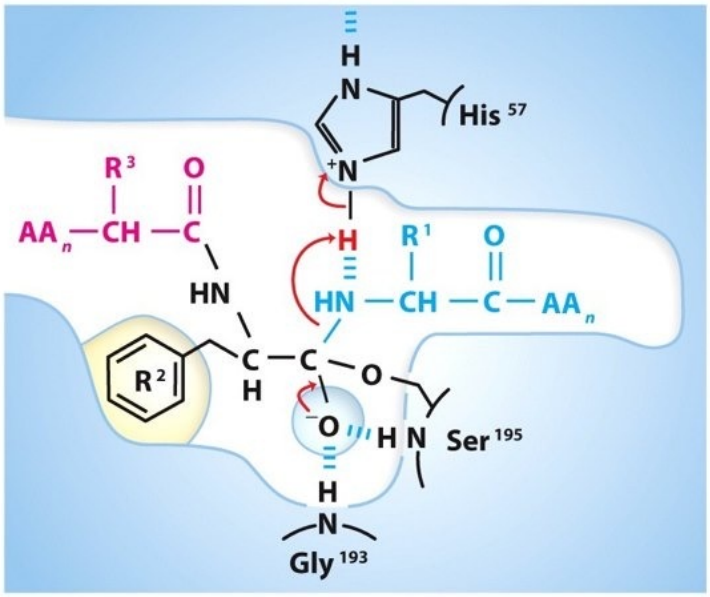


- His protonation makes Ser a strong nucleophile (acid-base catalysis).
- Ser O attacks carbonyl C, forming a tetrahedral structure (covalent catalysis).
- Negative charge on carbonyl O, stabilized in oxyanion hole by H bonds.

Step 3: Substrate Cleavage

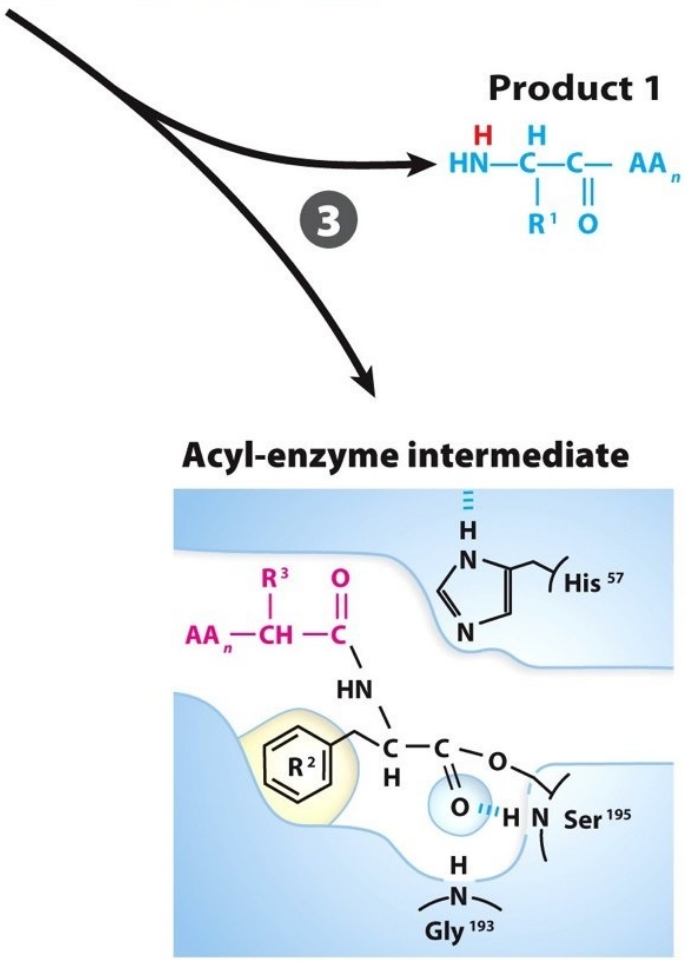
Short-lived intermediate* (acylation)

Instability of the negative charge on the substrate carbonyl oxygen leads to collapse of the tetrahedral intermediate; re-formation of a double bond with carbon displaces the bond between carbon and the amino group of the peptide linkage, breaking the peptide bond. The amino leaving group is protonated by His57, facilitating its displacement.

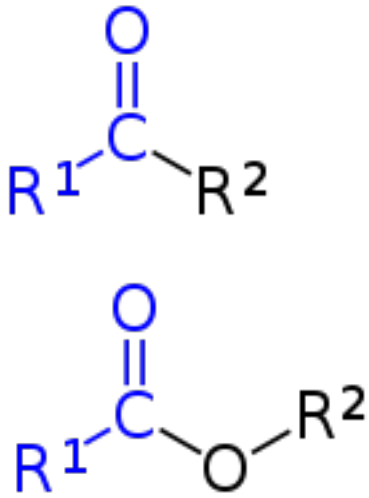


- Instability of negative charge on carbonyl O
- Collapse of tetrahedral intermediate
- Re-formation of double bond
- Breaking of peptide bond
- Amino leaving group protonated by His
- H goes from Ser residue to amino group

Step 3: Substrate Cleavage

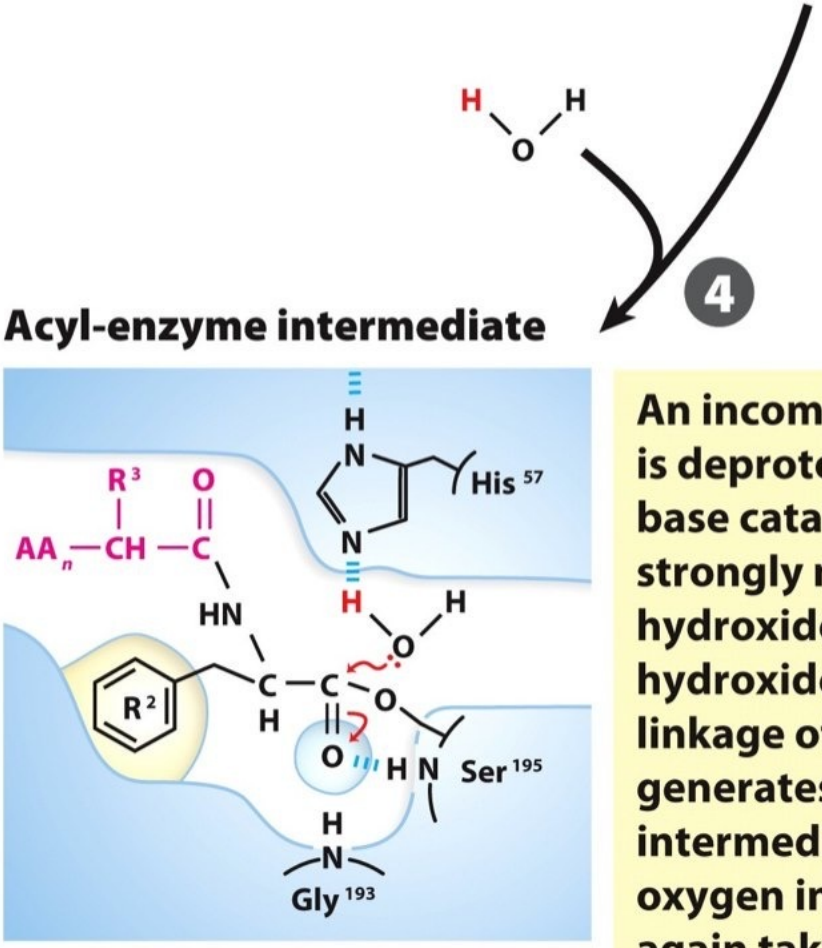


- Product 1 leaves (with a new amino group).
- Newly formed ester.
- Acyl-enzyme intermediate and acylation.



Acyl group

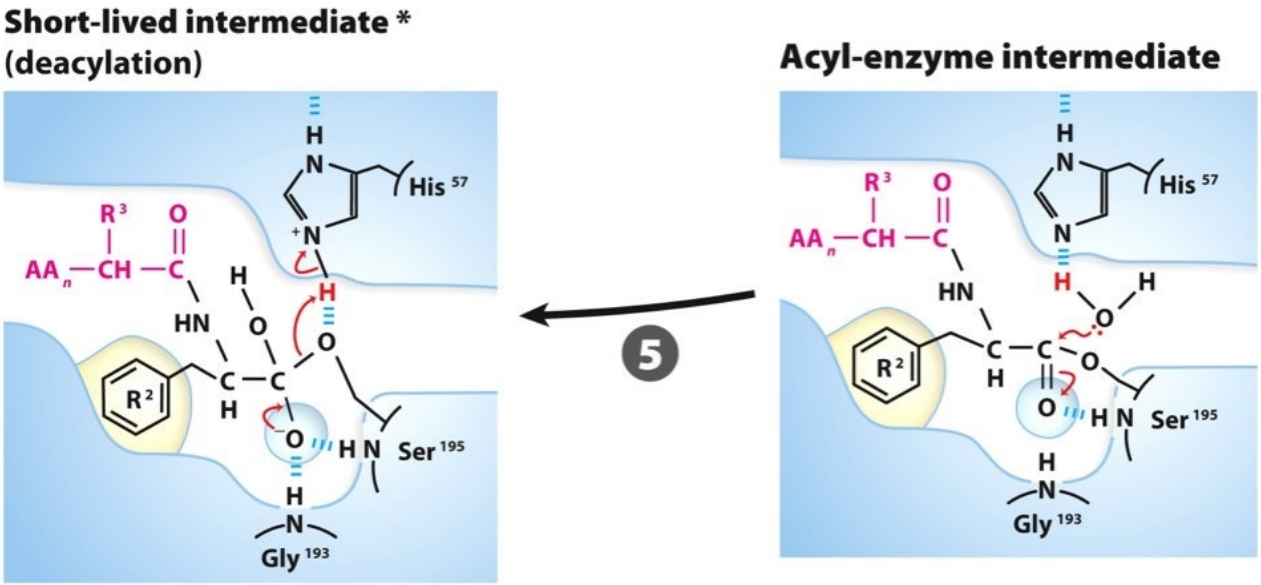
Step 4: Water Comes In



- Water deprotonation by His (acid-base catalysis).
- Hydroxide ion strong nucleophile.

An incoming water molecule is deprotonated by general base catalysis, generating a strongly nucleophilic hydroxide ion. Attack of hydroxide on the ester linkage of the acyl-enzyme generates a second tetrahedral intermediate, with oxygen in the oxyanion hole again taking on a negative charge.

Step 5: Water Attacks

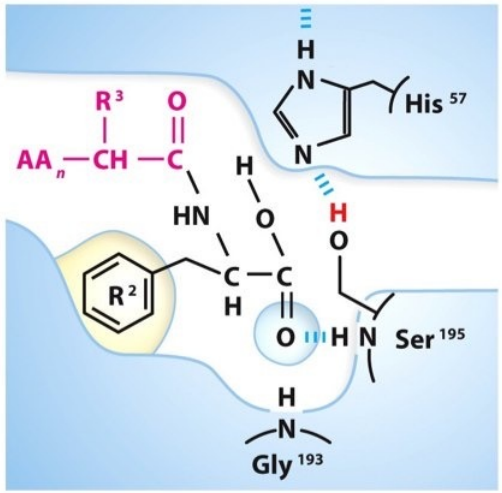


Collapse of the tetrahedral intermediate forms the second product, a carboxylate anion, and displaces Ser_{195}.

- Hydroxide O attacks carbonyl C, forming a second tetrahedral structure.
- Negative charge on carbonyl O, stabilized in oxyanion hole by H bonds.

Step 6: Break-off from Enzyme

Enzyme-product 2 complex



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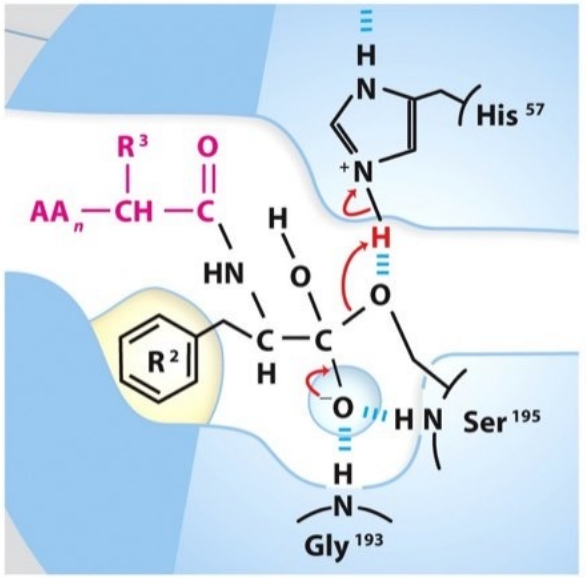
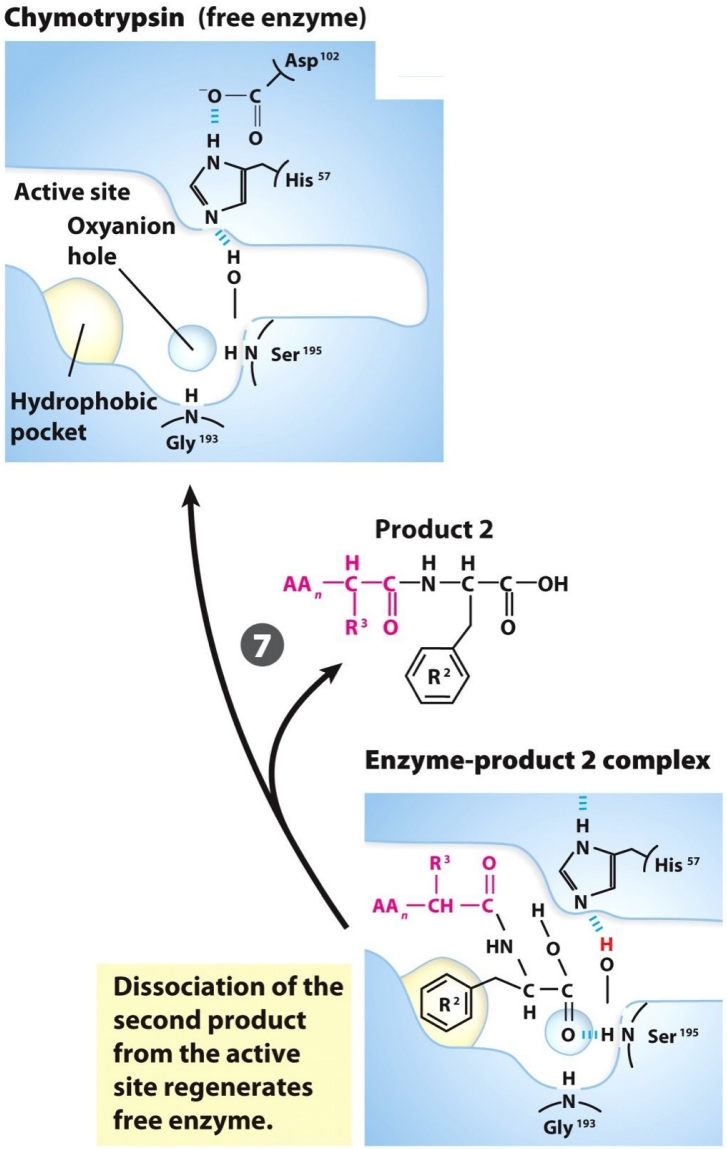
Short-lived intermediate * (deacylation)



Collapse of the tetrahedral intermediate forms the second product, a carboxylate anion, and displaces Ser_{195}.

- Instability of negative charge on carbonyl O.
- Collapse of tetrahedral intermediate.
- Re-formation of double bond.
- Breaking of ester bond.
- Hydroxyl leaving group protonated by His.
- H goes from water molecule to Ser residue.
- OH goes from water molecule to carboxyl group.

Step 7: Product Dissociates



- Product 2 leaves (with a new carboxyl group).

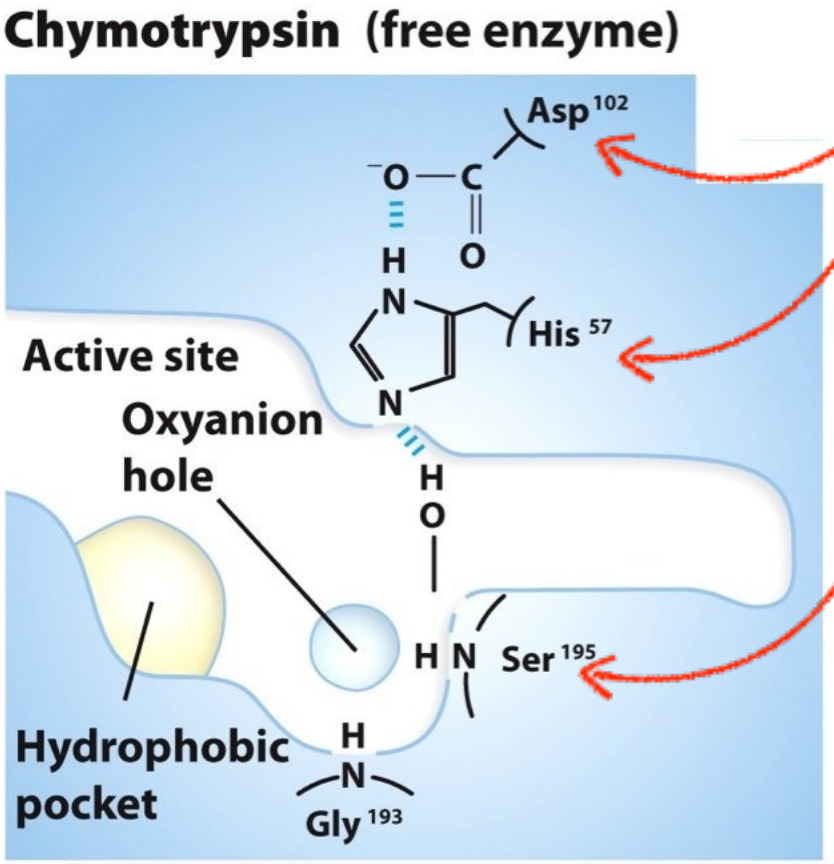
—C(=O)—NH— + **HOH** + Chymotrypsin-O**H**

↓

—C(=O)—**OH** + **H**NH— + Chymotrypsin-O**H**

- In product 1, H comes from enzyme Ser residue.
- In product 2, OH comes from water molecule.
- After catalysis, Ser H atom comes from water.

Catalytic Triad



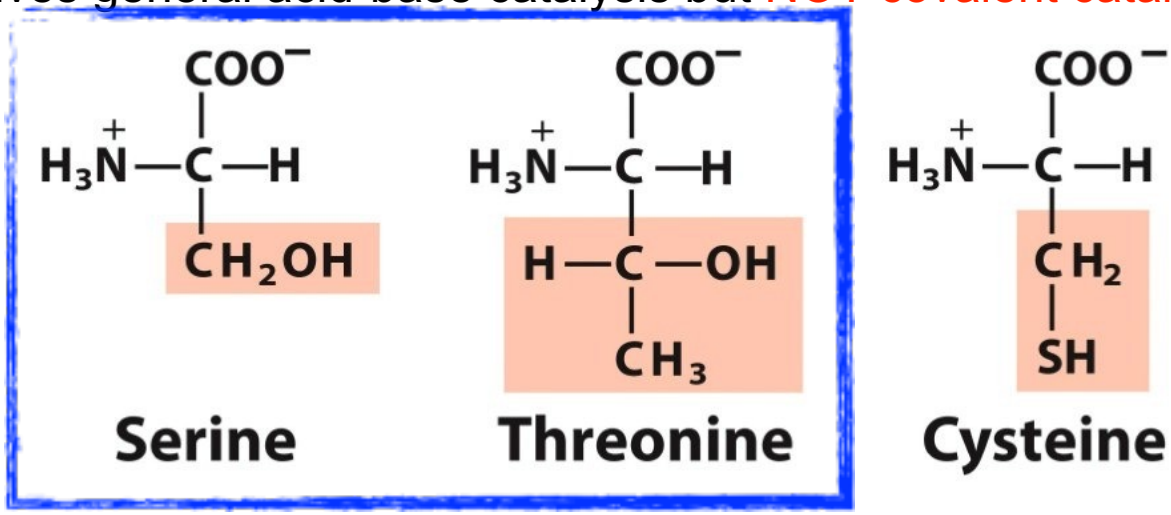
- Asp-His-Ser forms H-bonding network.
  - Ser pK_a generally too high.
  - Deprotonated Ser NOT present.
- Substrate binding induces conformational change.
- Stronger H-bond between Asp and His.
- His pK_a increases from 7 to >12.
- His acts as enhanced general base and deprotonates Ser.
- Ser acts as a strong nucleophile.

Amino acid	Abbreviation/ symbol	M_r*	pK_a values: pK_1 (—COOH)	pK_2 ($—NH_3^+$)	pK_R (R group)	pI
Serine	Ser S	105	2.21	9.15		5.68
Threonine	Thr T	119	2.11	9.62		5.87

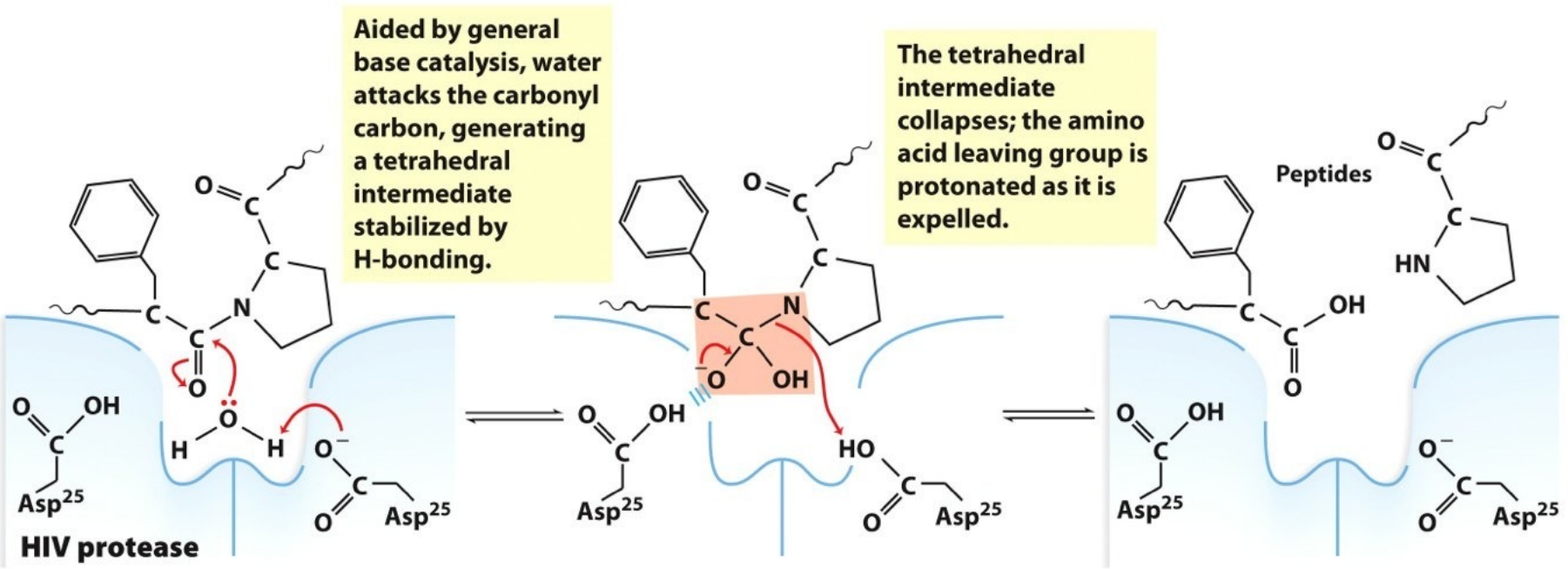
Protease

- Serine protease.
  - Deprotonated Ser hydroxyl group as nucleophile.
  - Involves general acid-base catalysis and covalent catalysis.
- Cysteine protease.
  - Deprotonated Cys thiol group as nucleophile.
  - Involves general acid-base catalysis and covalent catalysis.
- Aspartyl protease and Metalloprotease.
  - Activated water molecule as nucleophile.
  - Involves general acid-base catalysis but NOT covalent catalysis.

Amino acid for 6th week

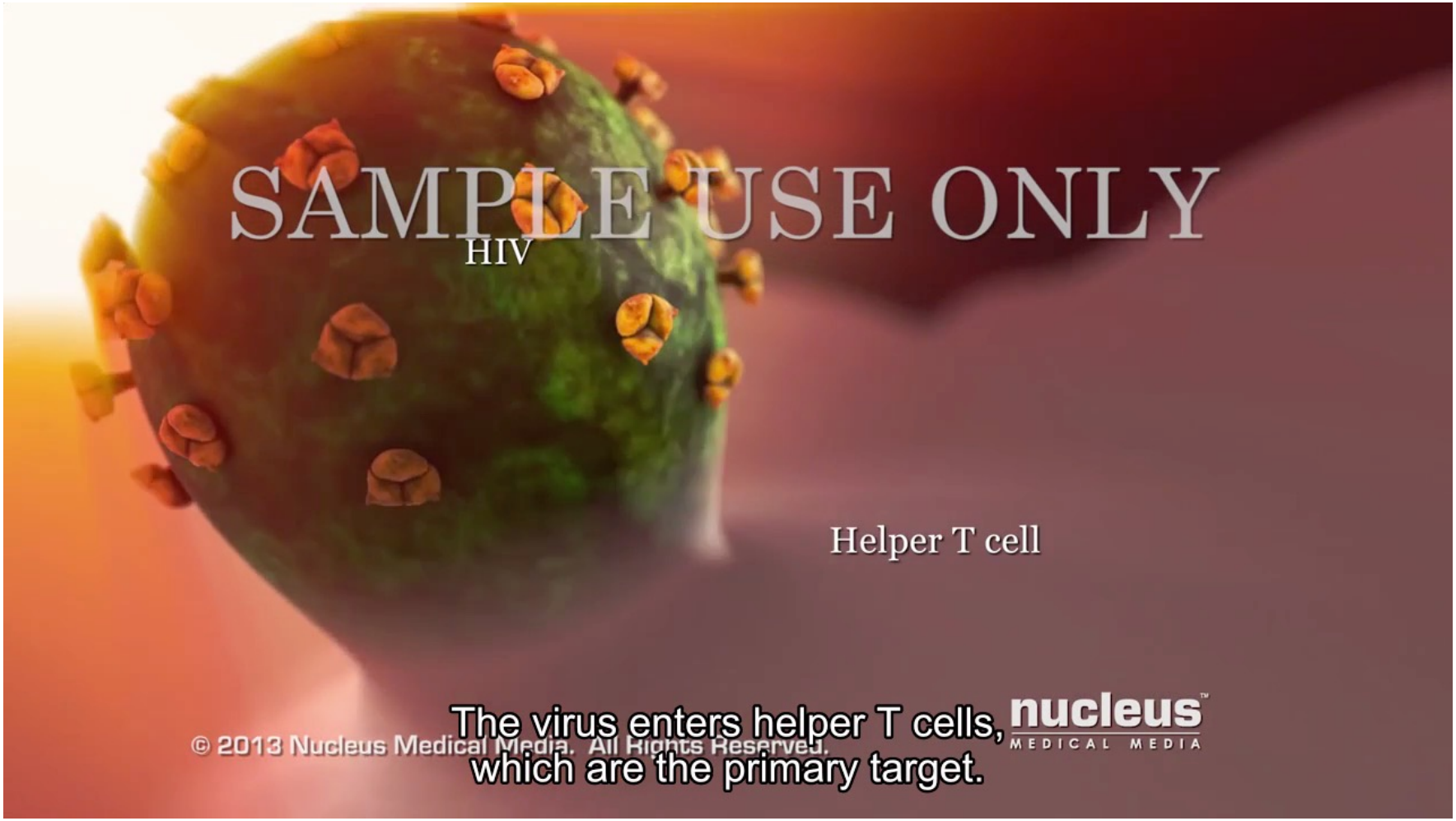


HIV Protease



- Aspartyl protease.
  - Asp deprotonates water and activated water molecule acts as nucleophile.
  - NO covalent bond between enzyme and substrate.
  - Tetrahedral intermediate similar to transition state.
- Cleaves peptide bonds between Phe and Pro most efficiently.

Immune System, HIV and AIDS



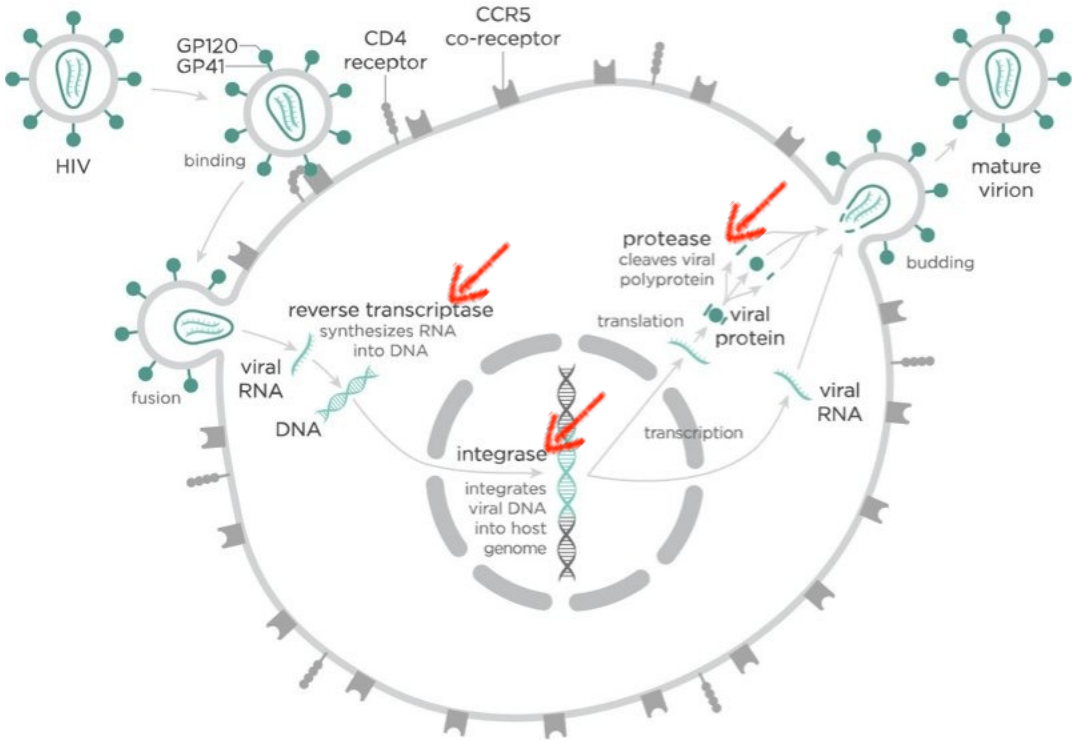
Immune System, HIV and AIDS

- Immune system fights off infections caused by foreign invaders such as bacteria and viruses
- HIV: Human Immunodeficiency Virus
  - 人类免疫缺陷病毒
- AIDS: Acquired Immunodeficiency Syndrome
  - 获得性免疫缺乏综合症
  - HIV's primary target is helper T cell
  - HIV kills helper T cells, weakens immune system
  - Opportunistic infections develop because body cannot defend itself

How HIV Transmits and How to Avoid

- HIV passes from person to person through infected body fluids:
  - Unprotected sex
  - Shared drug injection needles
  - Childbirth and breastfeeding
  - Contaminated blood and blood products
- How to avoid HIV:
  - Know your partner's HIV status
  - Limit sex to one uninfected partner
  - Use condoms
  - Avoid injectable illegal drugs or shared needles
  - Avoid intoxication from drugs and alcohol

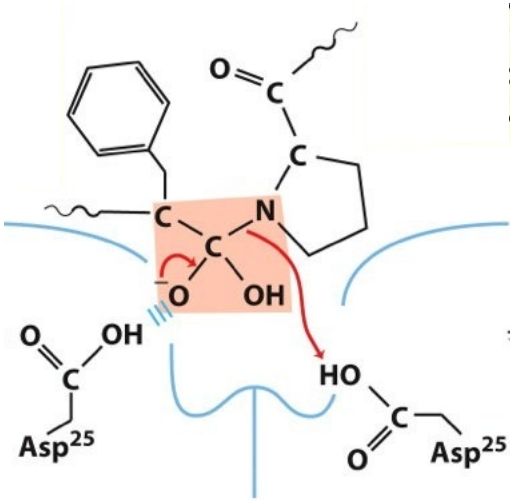
HIV Life Cycle

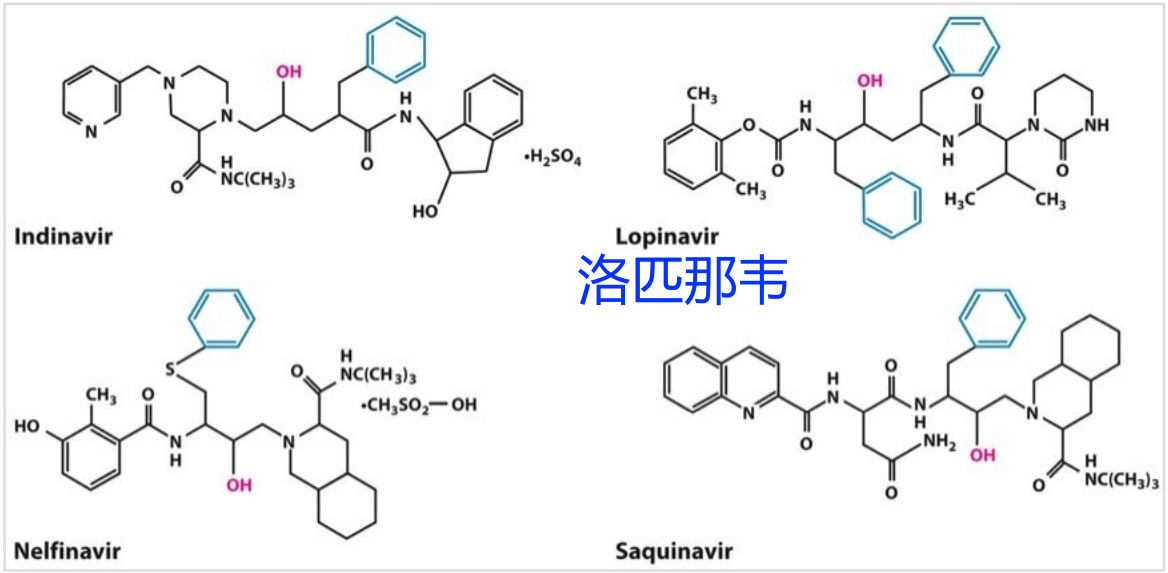


- HIV is a retrovirus.
  - RNA but NOT DNA genome.
- Reverse Transcriptase.
  - Directs synthesis of DNA sequence complementary to RNA genome.
- Integrase.
  - Inserts DNA into host chromosome.
- Protease.
  - Cut large polyproteins into individual proteins.

- No cure. Antiretroviral medications.
  - NOT completely remove virus.
  - Reduce HIV amount in the body.
  - Fusion/Entry inhibitors.
  - Inhibitors of reverse transcriptase, integrase, or protease.

HIV Protease Inhibitors





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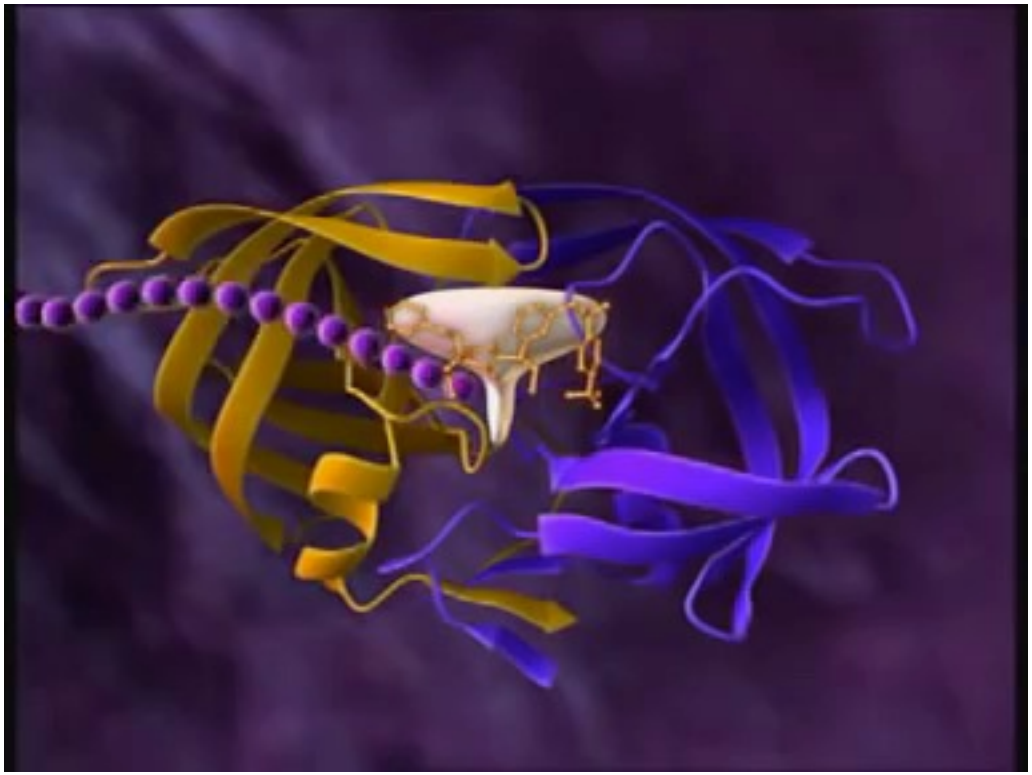
Mortality rate drop by 80%

- All inhibitors share a core structure.
  - A main chain with a hydroxyl group.
  - A branch containing a benzyl group.
- **Inhibitors work as a transition-state analog.**

HIV Replication and Therapy



Viral entry

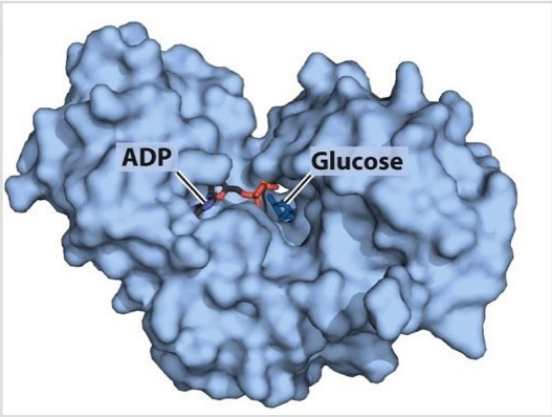
- Viral gp120 and gp41 proteins
- CD4 and CCR5 on T cell

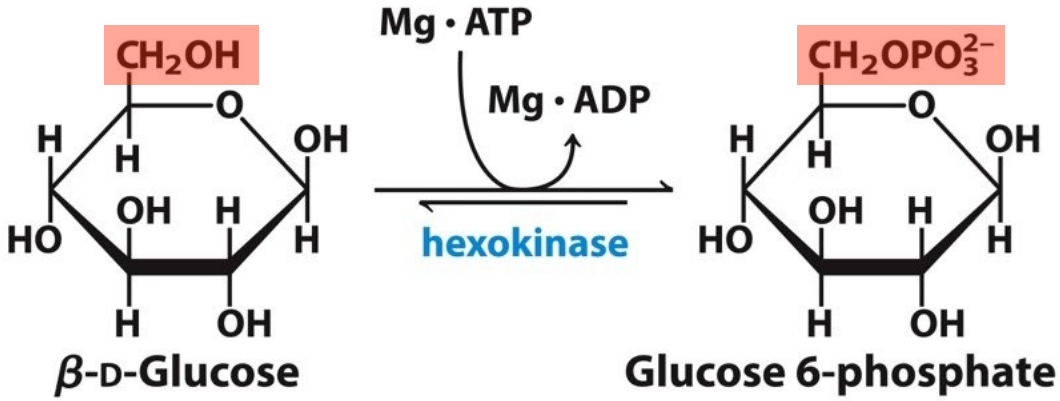
Inhibitors of four key steps:

- Host cell entry
- Reverse Transcription
- Integration
- Proteolytic cleavage

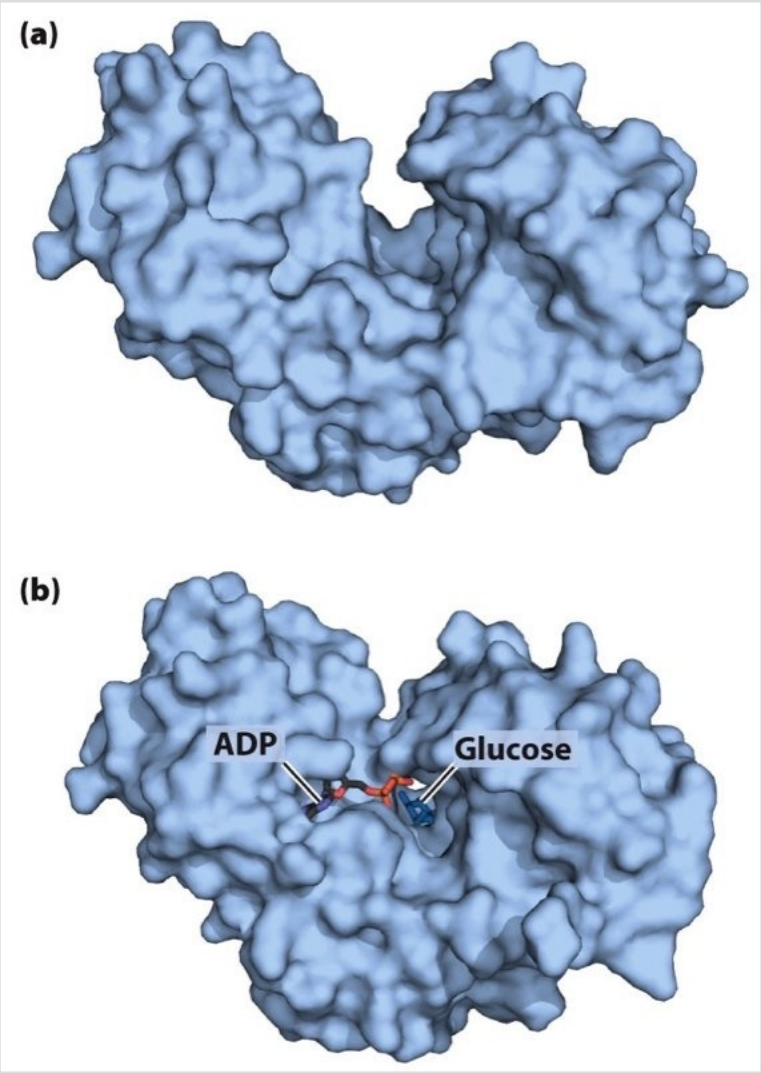
What Is Hexokinase?

- Phosphorylates hexose (six-carbon sugar).
  - Glucose is the most important substrate.
- Forms hexose phosphate.
  - Glucose 6-phosphate is the most important product.
- Transferase. Part of glycolysis.
  - Transfer phosphate group from ATP to substrate.





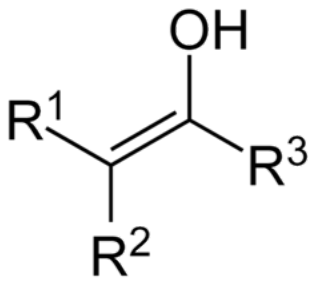
Binding Induces Conformational Change



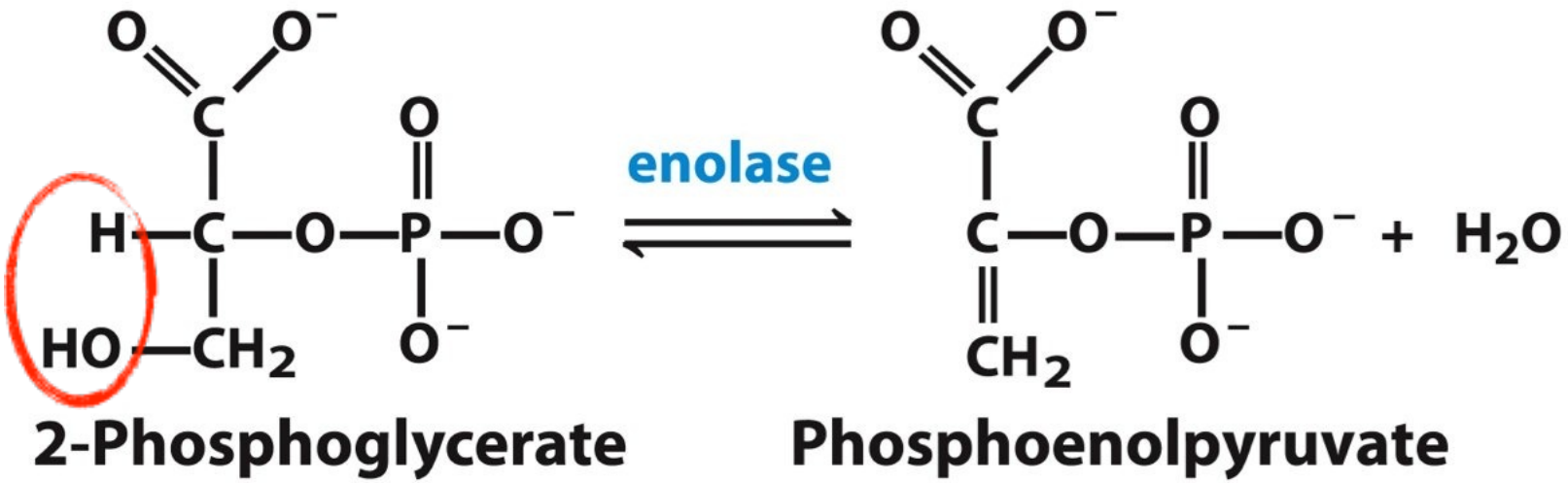
- When glucose is NOT present:
  - Active site residues NOT in position for reaction.
- When glucose binds:
  - **Binding induces conformational change**.
  - Hexokinase changes to catalytically active form.

What Is Enolase?

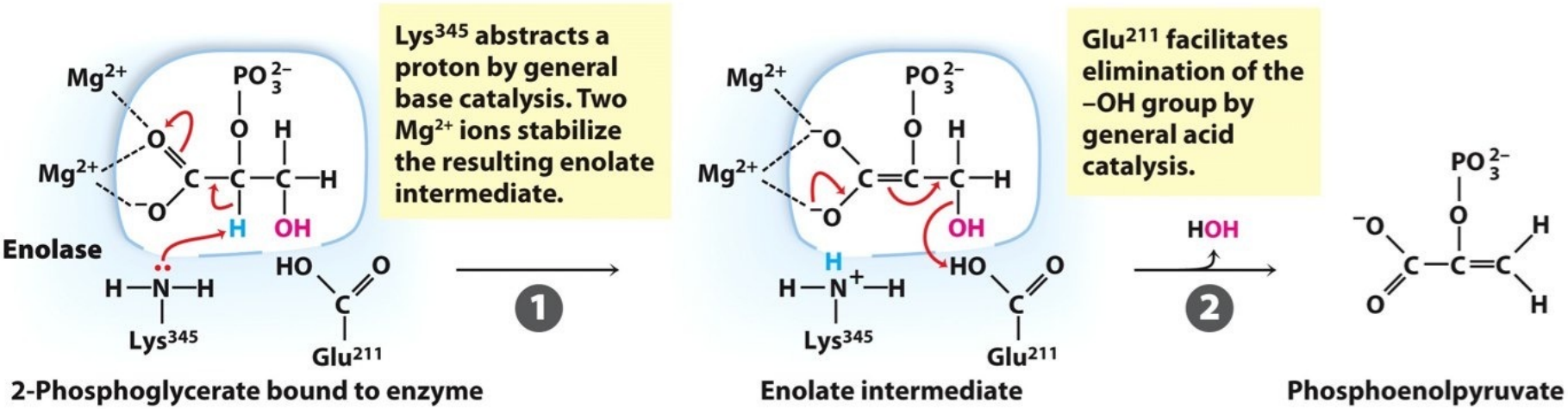
- Catalyze reversible dehydration of 2-phosphoglycerate to phosphoenolpyruvate.
  - Also part of glycolysis.
- Lyase. Metalloenzyme (Mg^{2+} as cofactor)
  - Cleave carbon-oxygen bond.

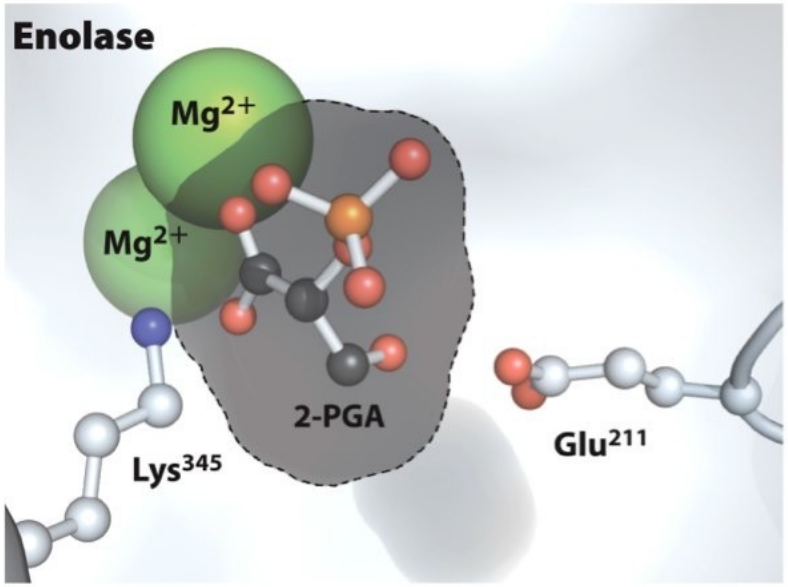


Enol



Enolase Reaction Mechanism





- General acid-base catalysis.
  - Lys deprotonates C-2.
  - Glu protonates -OH leaving group.
- Mg^{2+} ions.
  - Ionic interactions with carboxyl group.
  - Stabilization of transition state.

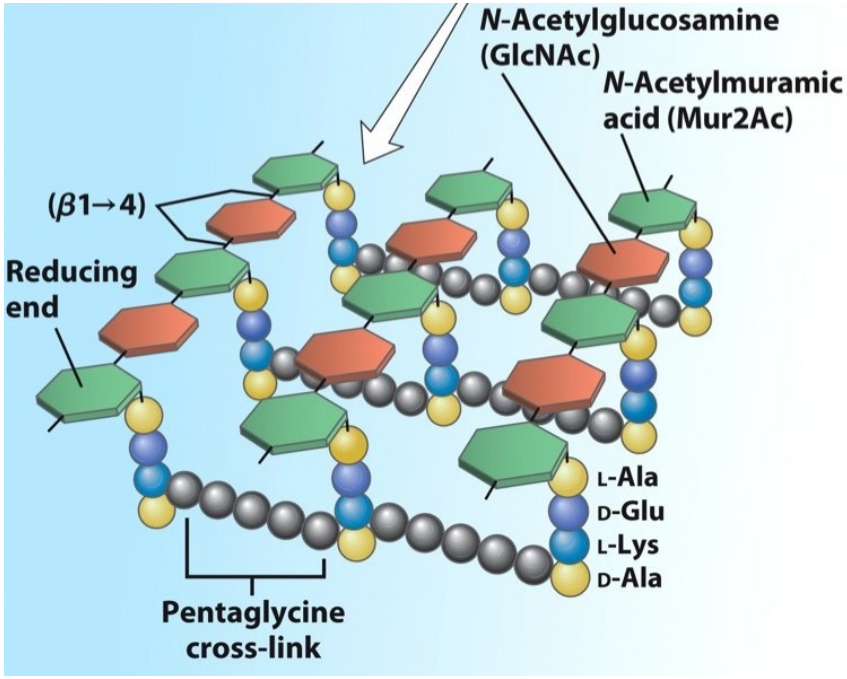
Lysozyme

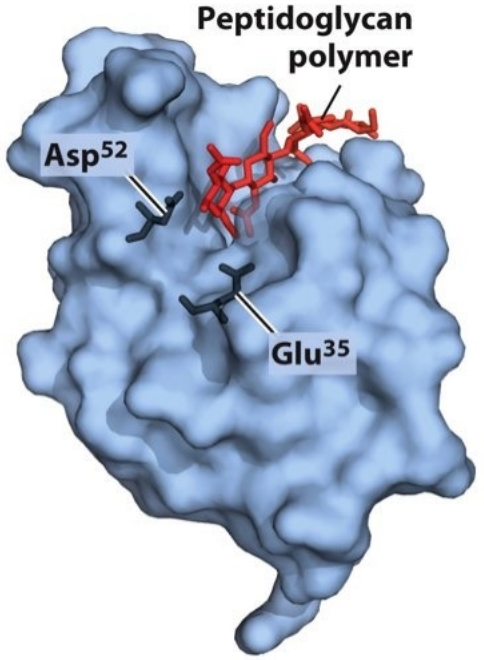
- Attack peptidoglycan (bacterial cell wall).
  - Abundant in secretions such as tear, saliva, milk and mucus.
  - Also present inside a cell (macrophage).
  - Found in egg white.
- Antibacterial action (1922 Alexander Fleming).

In the first experiment nasal mucus from the patient, with coryza, was shaken up with five times its volume of normal salt solution, and the mixture was centrifuged. A drop of the clear supernatant fluid was placed on an agar plate, which had previously been thickly planted with *M. lysodeikticus*, and the plate was incubated at 37° C. for 24 hours, when it showed a copious growth of the coccus, except in the region where the nasal mucus had been placed. Here there was complete inhibition of growth, and this inhibition extended for a distance of about 1 cm. beyond the limits of the mucus.

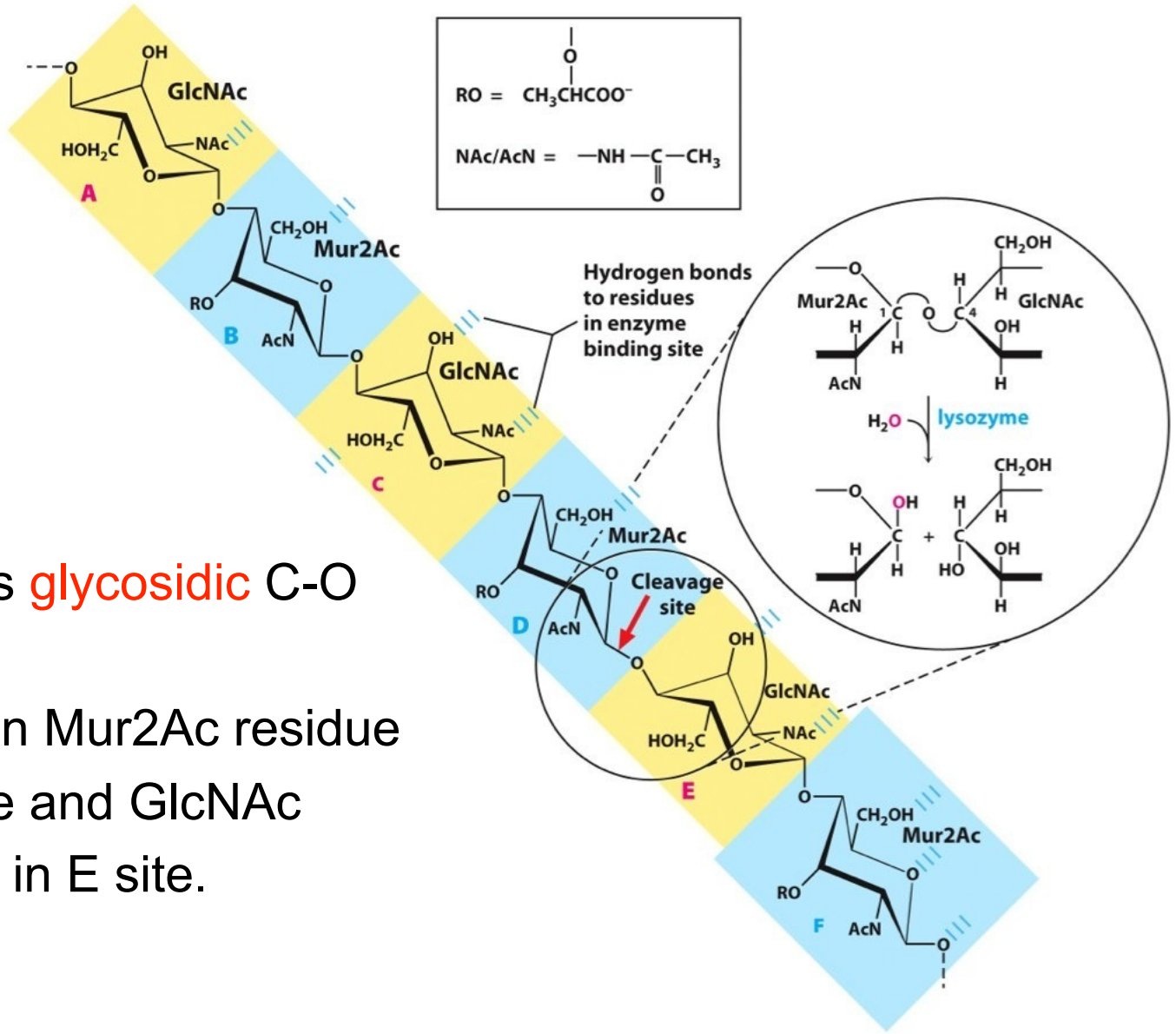
Peptidoglycan and Lysozyme

- Peptidoglycan is a polysaccharide cross-linked by peptides, found in many bacterial cell walls.
- Cleavage of cell wall leads to lysis of bacteria.
- Lysozyme is an antibacterial enzyme.



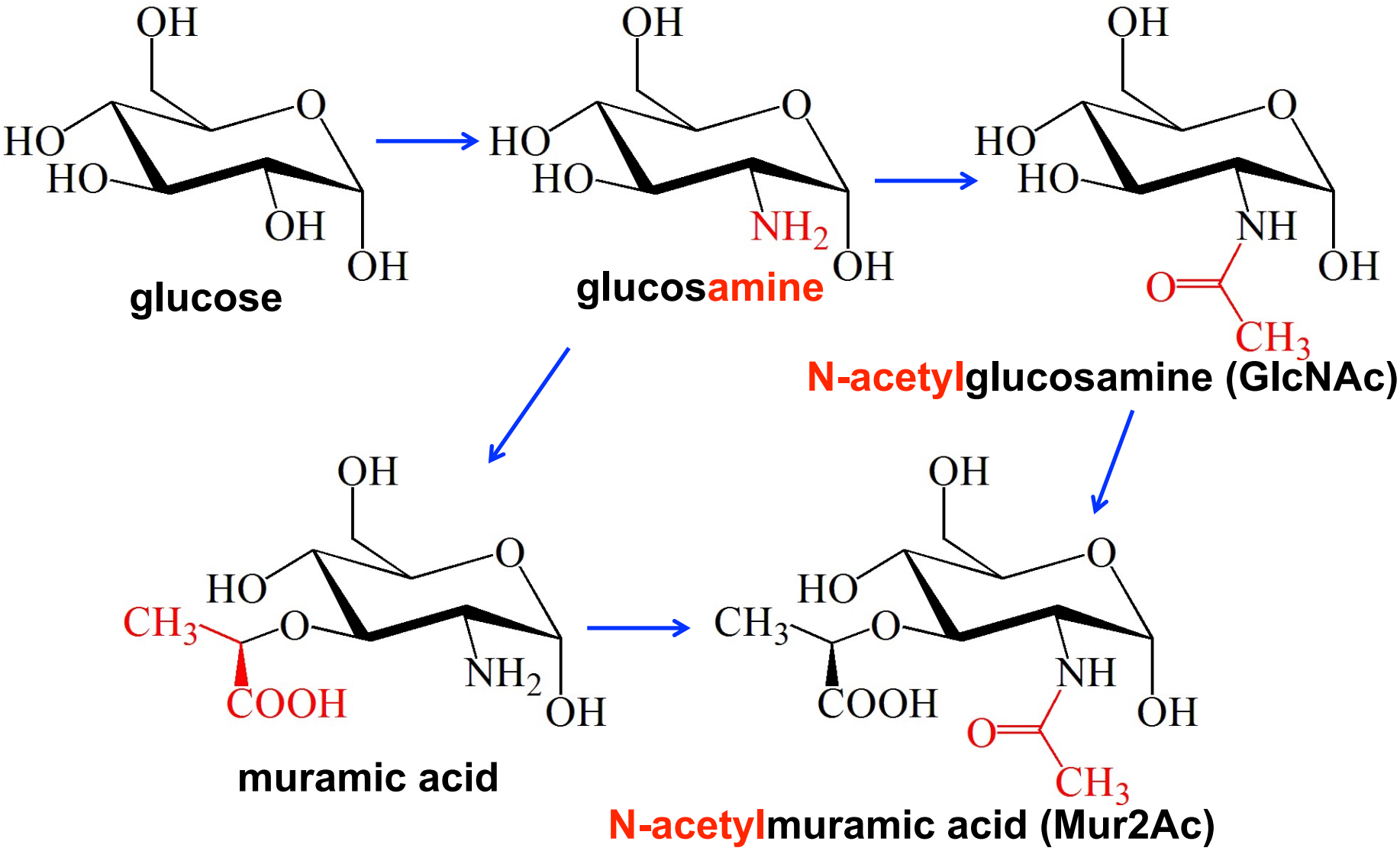


Lysozyme-Catalyzed Reaction

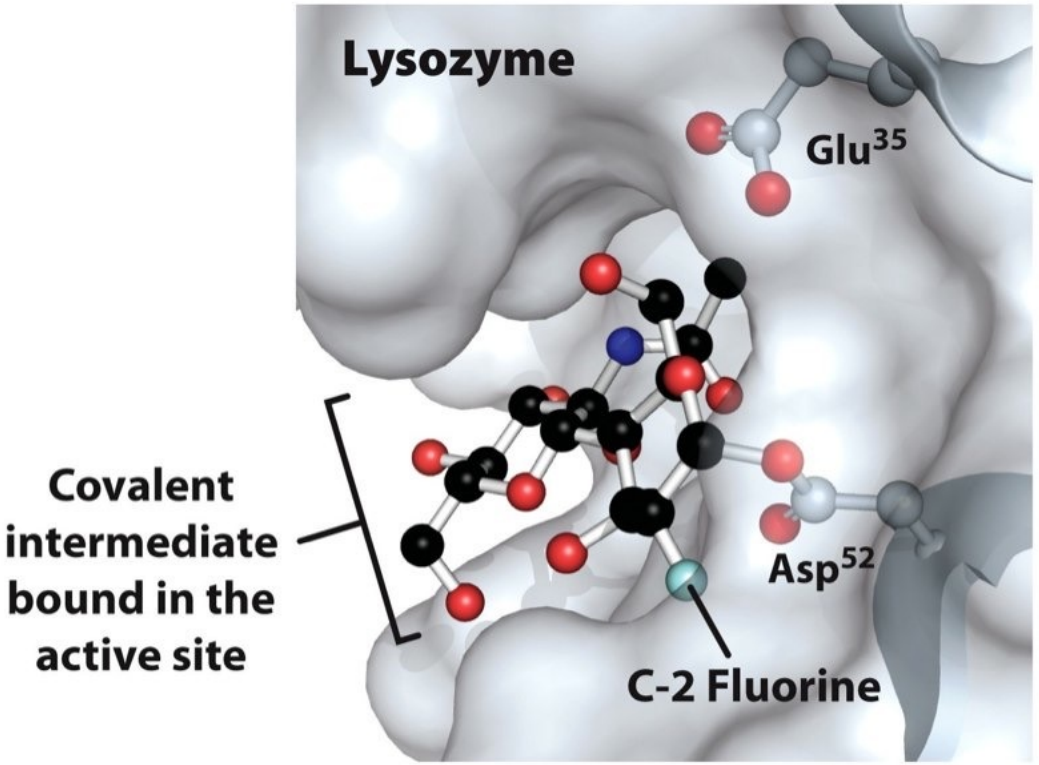


- Cleaves glycosidic C-O bond
- Between Mur2Ac residue in D site and GlcNAc residue in E site.

GlcNAc and Mur2Ac



Active Site Residues

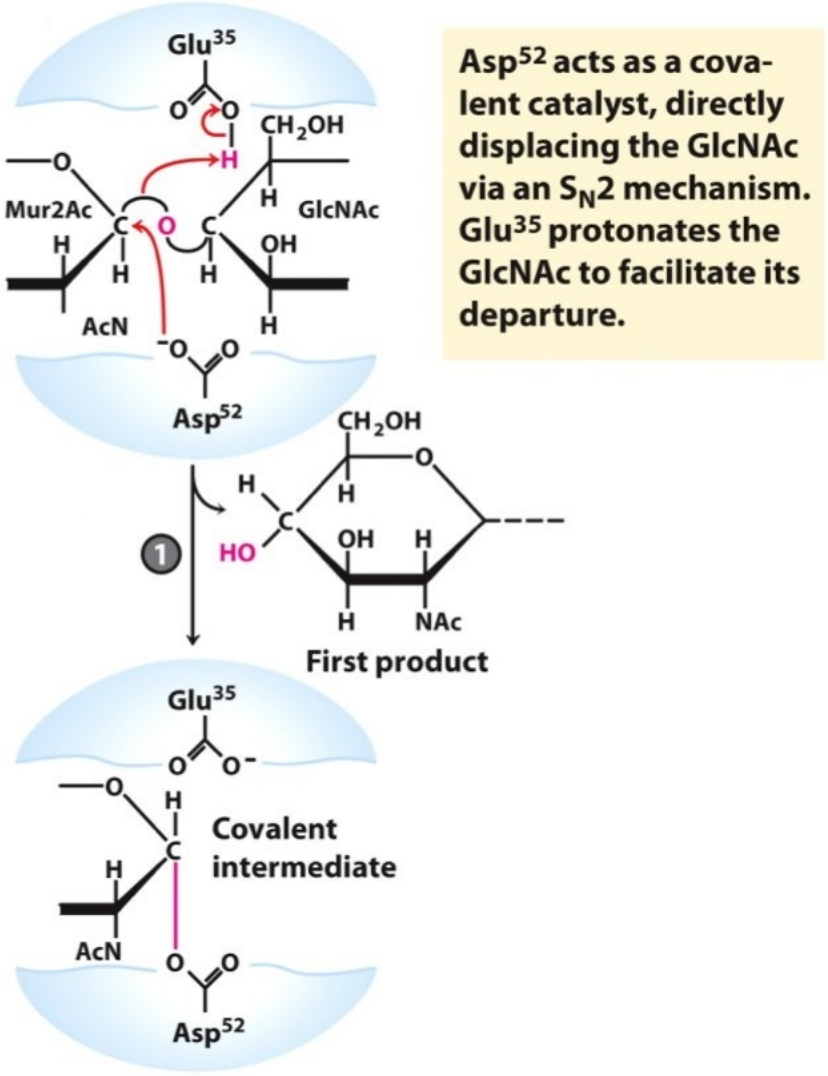


- Aspartate 52
  - Nucleophile.
  - Covalent catalysis.
- Glutamate 35
  - General acid-base catalysis.
  - Protonate and deprotonate.

Two Nucleophilic Attacks

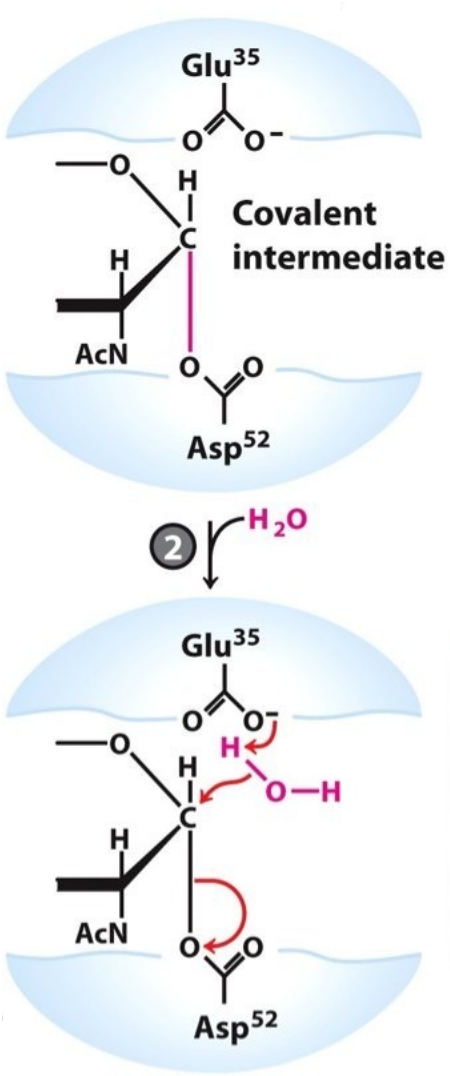
1. Asp 52 acts as a nucleophile to attack carbon #1 in the first step.
2. Glu 35 acts as a general acid and protonates leaving group in transition state.
3. Glu 35 acts as a general base and deprotonates water in the second step.
4. Deprotonated water acts as a nucleophile to attack covalent glycosyl-enzyme intermediate.

First Nucleophilic Attack



- Aspartate 52
  - Nucleophile
  - Attacks C #1 in Mur2Ac
  - Breaks glycosidic C-O bond
  - Covalent catalysis
- Glutamate 35
  - General acid catalysis
  - Protonates leaving GlcNAc
  - First product leaves

Second Nucleophilic Attack

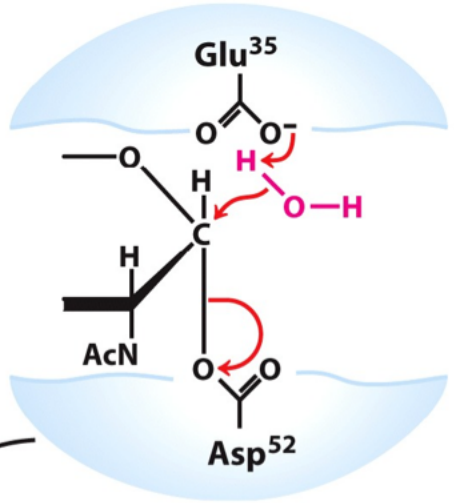


Glu35 acts as a general base catalyst to facilitate the S_N2 attack of water, displacing Asp52 and generating product.

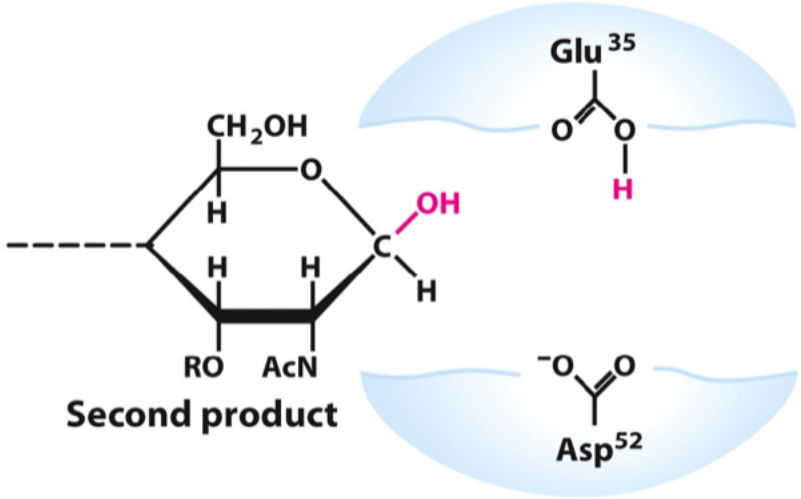
- Glutamate 35
  - General base catalysis.
  - Deprotonates water molecule.
- Deprotonated water
  - Nucleophile.
  - Attacks C #1 in Mur2Ac.
  - Breaks C-O bond.

Catalysis Completion

- Lysozyme regenerated
  - Aspartate 52
  - Glutamate 35
- Product 2 leaves



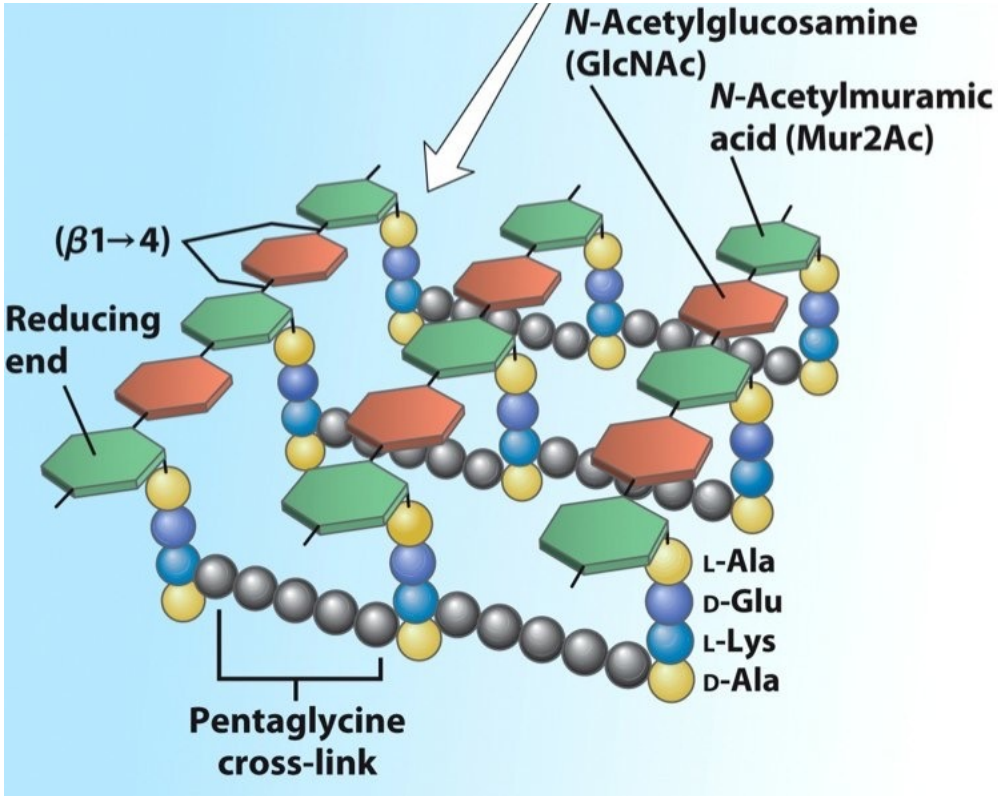
Glu35 acts as a general base catalyst to facilitate the S_N2 attack of water, displacing Asp52 and generating product.



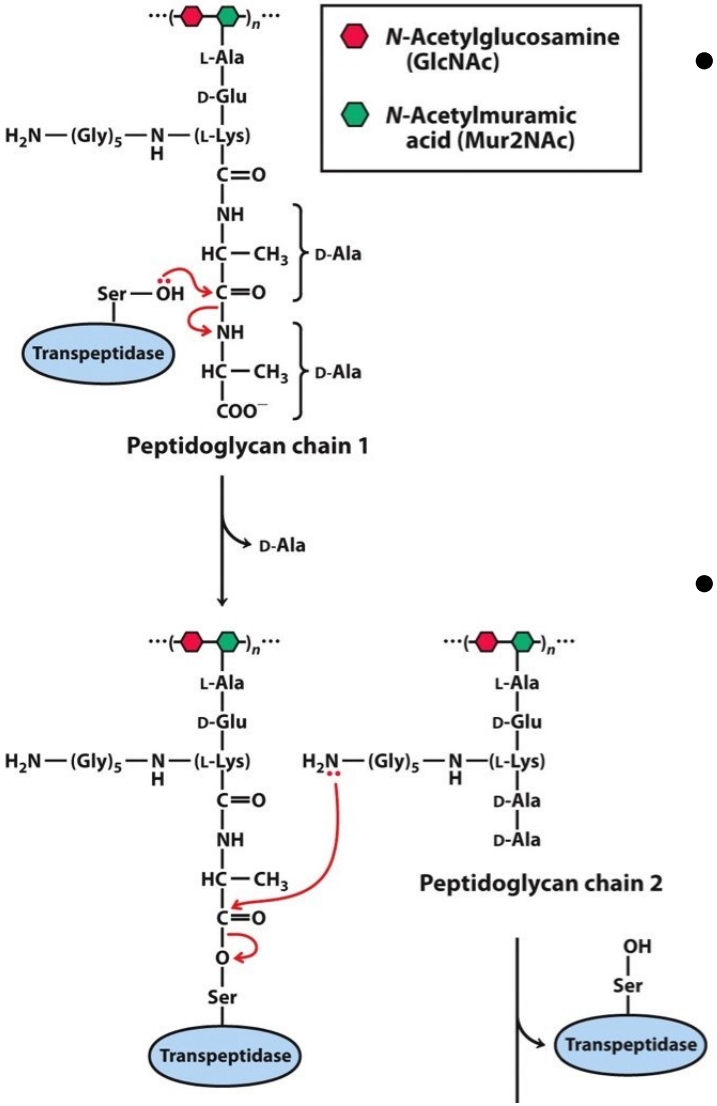
- In product 1 (GlcNAc) H comes from Glu residue.
- In product 2 (Mur2Ac) OH comes from water.
- In regenerated Glu H comes from water.

Peptidoglycan

- Peptidoglycan is a polysaccharide cross-linked by peptides, found in many bacterial cell walls.
- Inhibition of peptidoglycan synthesis leads to death of bacteria.



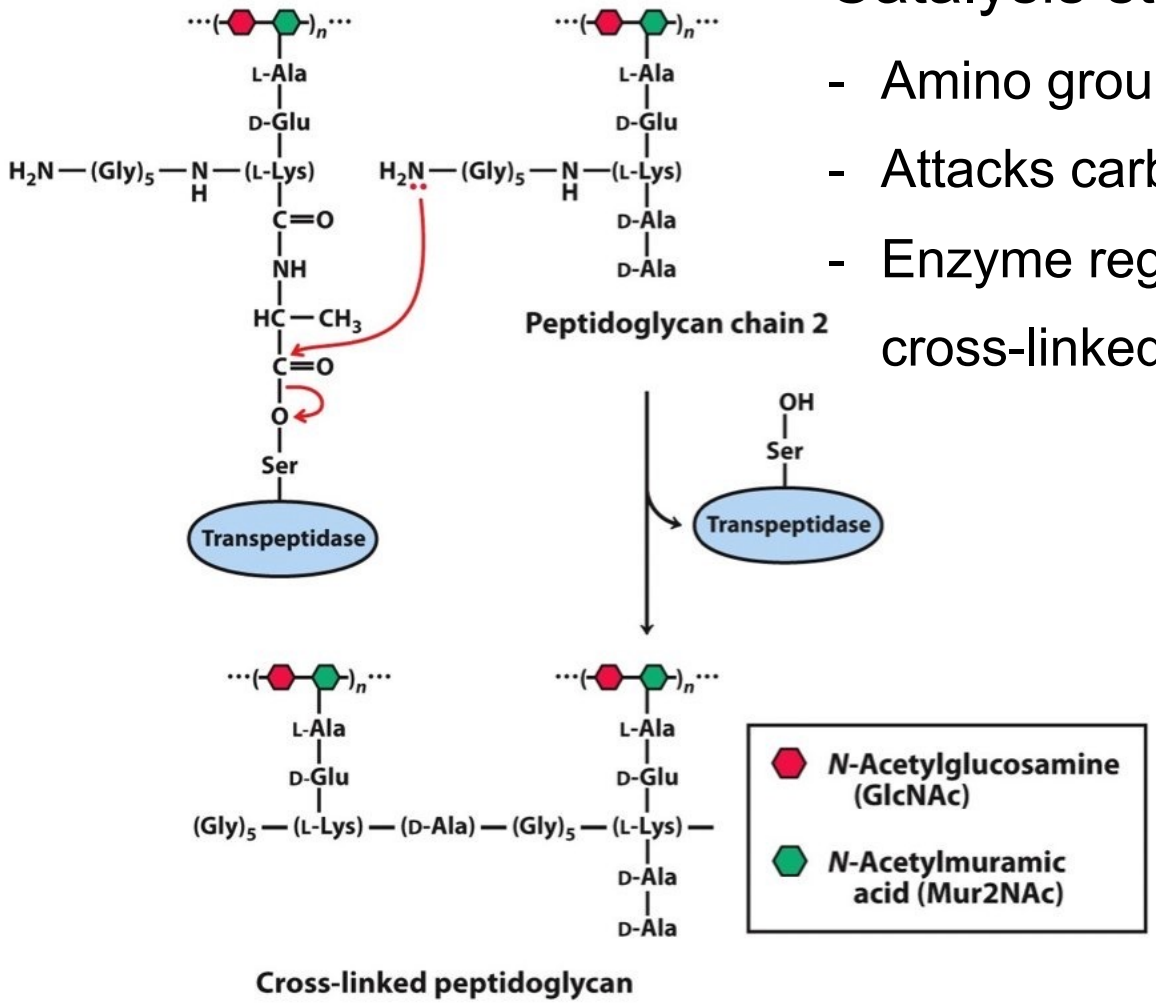
Part of Peptidoglycan Synthesis

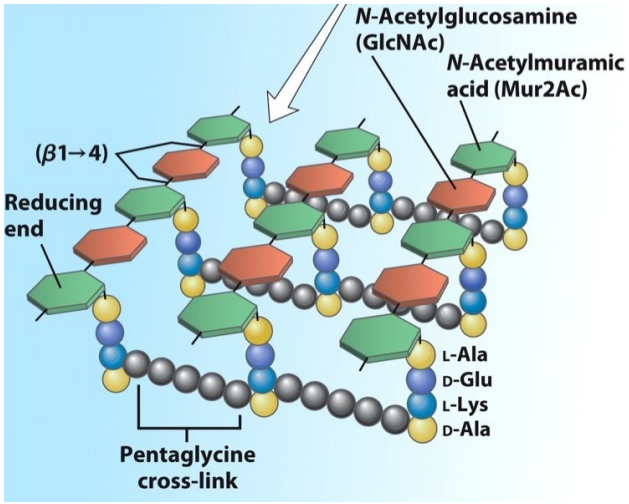


- Transpeptidase
  - Bacterial enzyme.
  - Involved in bacterial cell wall synthesis.
  - Cross-links peptide side chains of peptidoglycan strands.
- Catalysis step 1
  - Ser acts as nucleophile.
  - Attacks carbonyl carbon of peptide bond between two D-Ala residues.
  - covalent catalysis and D-Ala leaves.

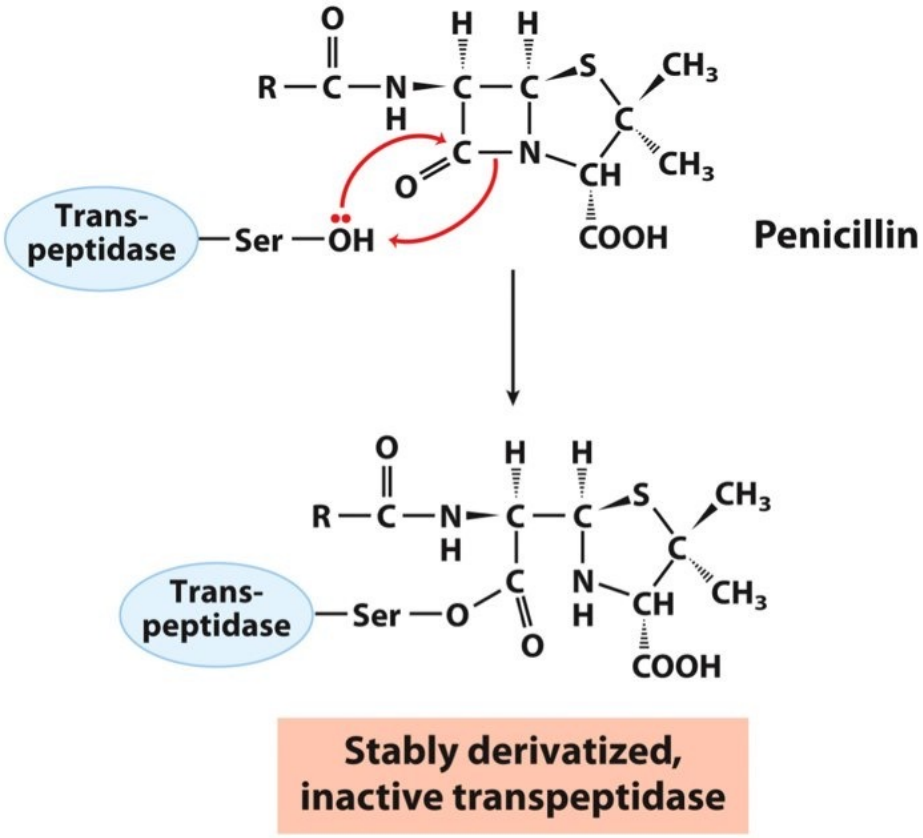
Part of Peptidoglycan Synthesis

- Catalysis step 2
  - Amino group acts as nucleophile.
  - Attacks carbonyl carbon of ester bond.
  - Enzyme regenerated and peptidoglycan cross-linked.





Transpeptidase Inhibition by Penicillin



- Transpeptidase active site Ser attacks carbonyl carbon of peptide bond in penicillin.
- Results in a covalent acyl-enzyme product.
- Product hydrolysis is so slow that enzyme cannot be regenerated, and so transpeptidase is inactivated.

Summary 6.4 Examples of Enzymes

- Chymotrypsin is a serine protease, featuring general acid-base catalysis, covalent catalysis, and transition state stabilization.
- Hexokinase provides a good example of induced fit.
- Enolase reaction proceeds via metal ion catalysis.
- Lysozyme makes use of covalent catalysis and general acid-base catalysis.

Enzymes

6.1 An Introduction to Enzymes

6.2 How Enzymes Work

6.3 Enzyme Kinetics

6.4 Examples of Enzymatic Reactions

6.5 Regulatory Enzymes

Enzyme Activity Can Be Regulated

- Regulatory enzymes exhibit increased or decreased catalytic activity in response to certain signals.
  - Much faster than increasing or decreasing amount of enzymes.
- Enzyme activity can be regulated in a variety of ways:
  - Allosteric enzyme (reversible, noncovalent, modulator)
  - Covalent modification (reversible)
  - Regulatory protein (reversible)
  - Proteolytic cleavage (irreversible)

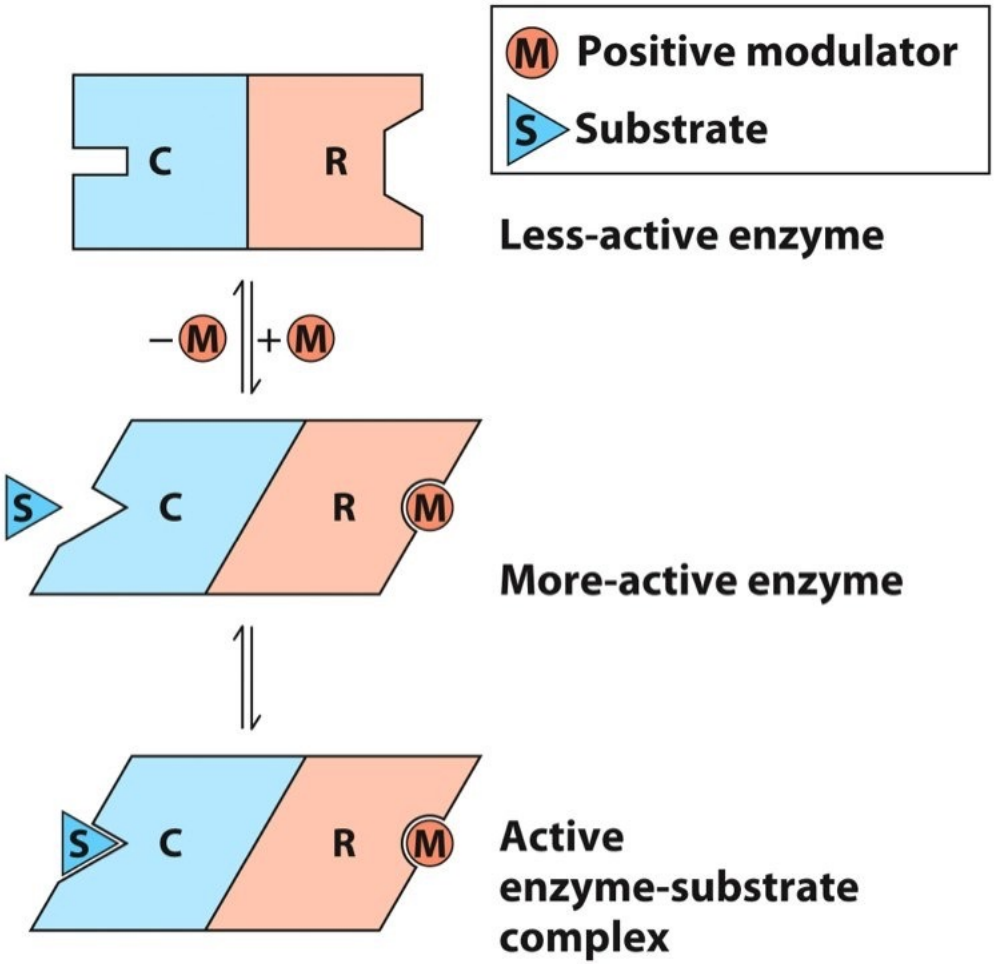
Allosteric Protein

- Allosteric protein
  - Binding of a ligand to one site affects the binding properties of **a different site**, on the same protein
  - Ligand, referred to as modulator
  - Can be positive or negative
- Modulator
  - Allosteric activator or allosteric inhibitor
  - modulator = ligand, homotropic interaction
  - modulator ≠ ligand, heterotropic interaction

Conformational Change Upon Binding

- Allosteric enzyme.
  - Binding of modulator causes **conformational change**, and affects the catalytic activity of enzyme.
  - Can have one or more regulatory, or allosteric, sites for binding modulator.
  - Each regulatory site is specific for its modulator.
- Modulator.
  - Allosteric activator or allosteric inhibitor
  - modulator = substrate, homotropic regulation
  - modulator ≠ substrate, heterotropic regulation

Conformational Change Upon Binding



- Substrate-binding site
  - Catalytic subunit
- Modulator-binding site
  - Regulatory subunit

Modulator binding

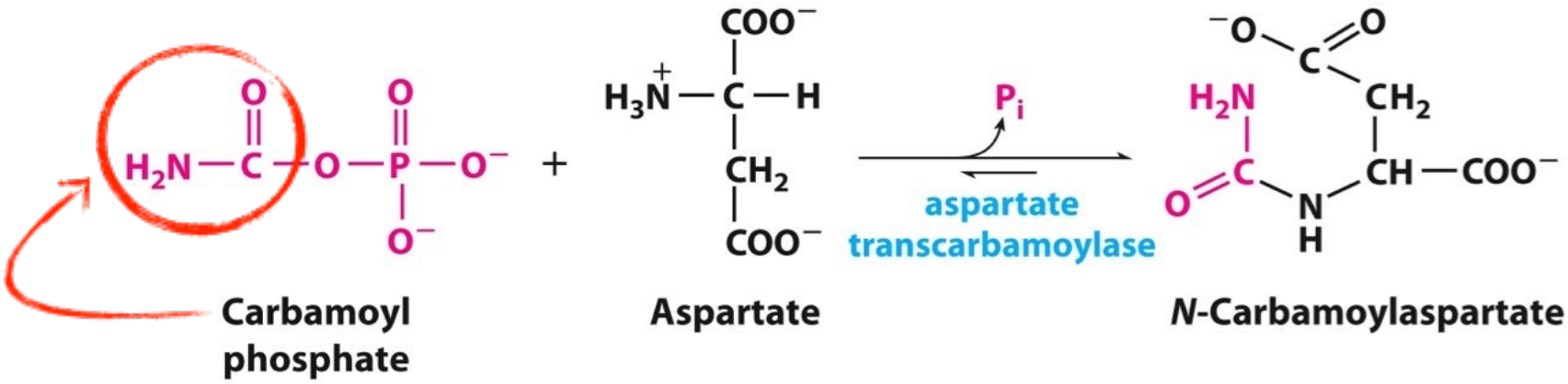
↓

Conformational change

↓

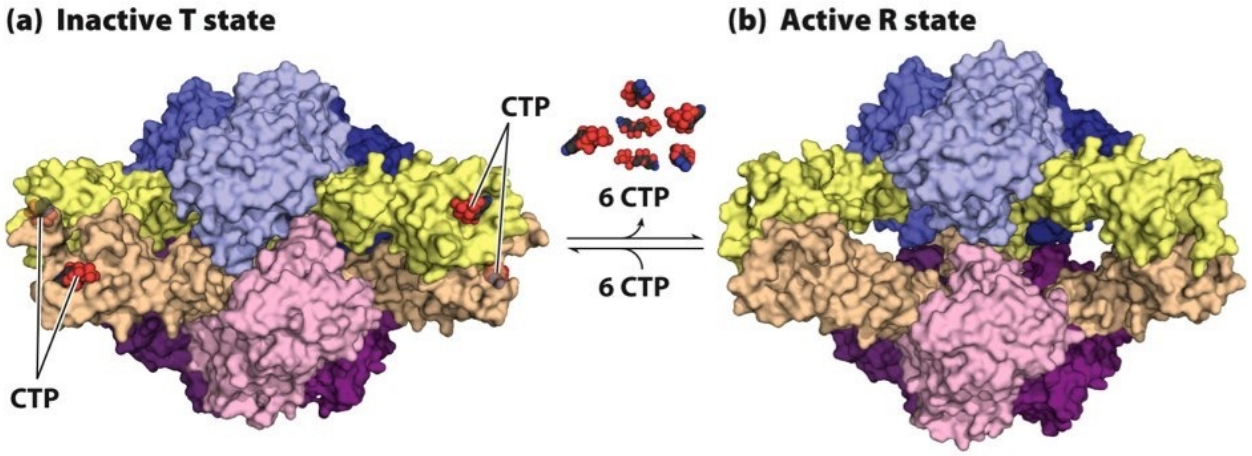
Active catalytic subunit

Aspartate Transcarbamoylase (ATCase)



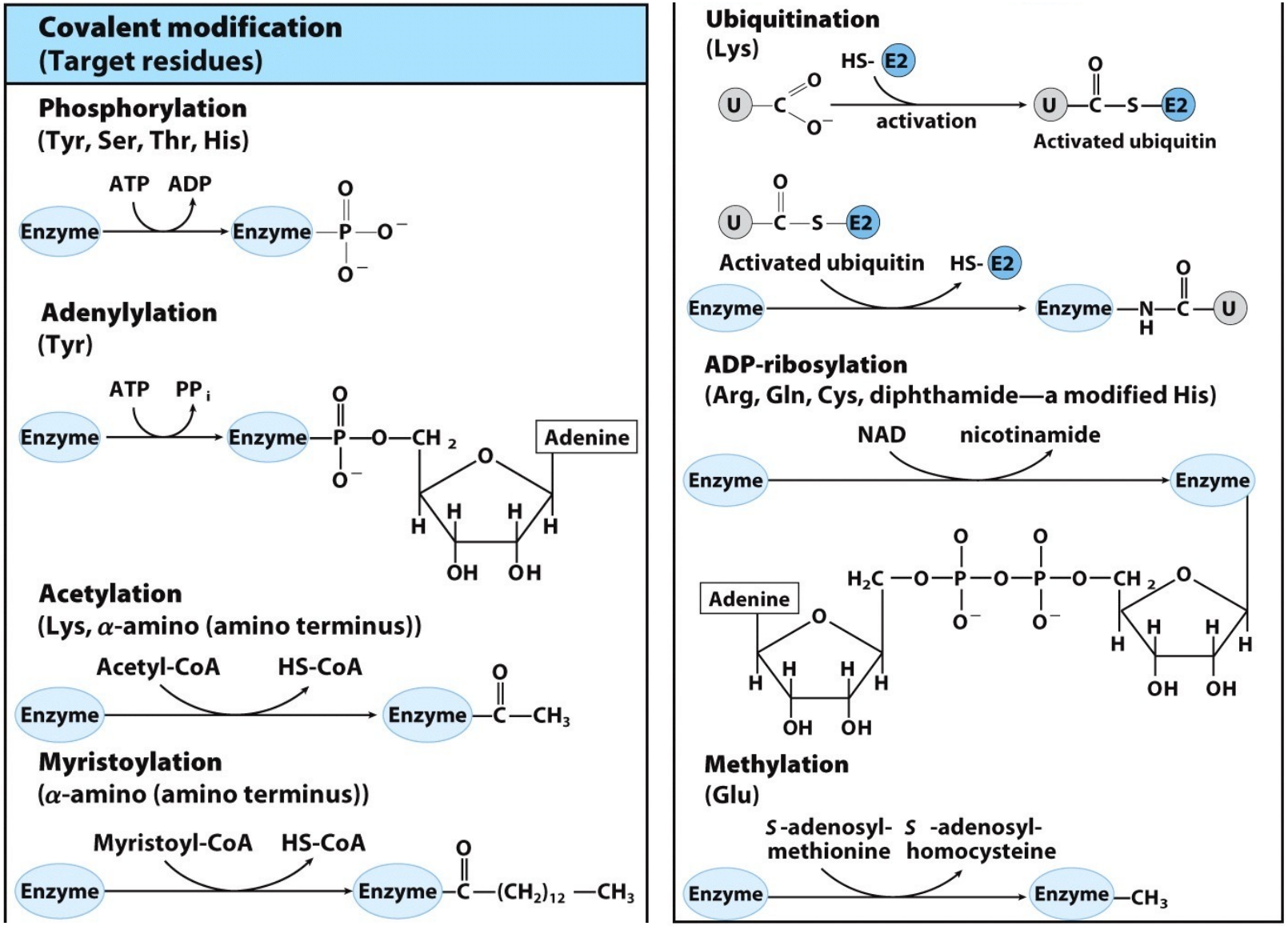
- Catalyzes an early step in biosynthesis of pyrimidine nucleotides.
  - Pyrimidine nucleotides include CTP and UTP.
- 12 polypeptide chains.
  - 6 catalytic subunits.
  - 6 regulatory subunits.

Allosteric Behavior of ATCase



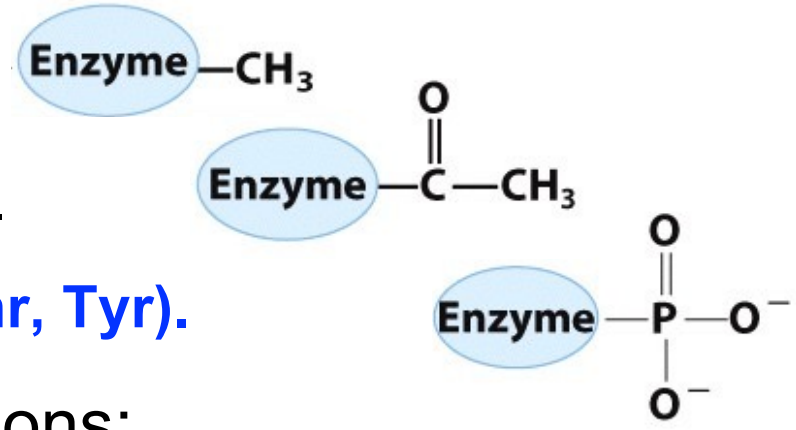
- Regulatory subunits have binding sites for CTP and ATP.
- CTP functions as a negative regulator.
  - CTP is one of end products of biosynthesis pathway.
  - When CTP is abundant, negative regulation limits ATCase activity.
- ATP functions as a positive regulator.
  - High concentrations of ATP indicates robust cellular metabolism.
  - Additional pyrimidine nucleotides needed to support RNA transcription.

Reversible Covalent Modification

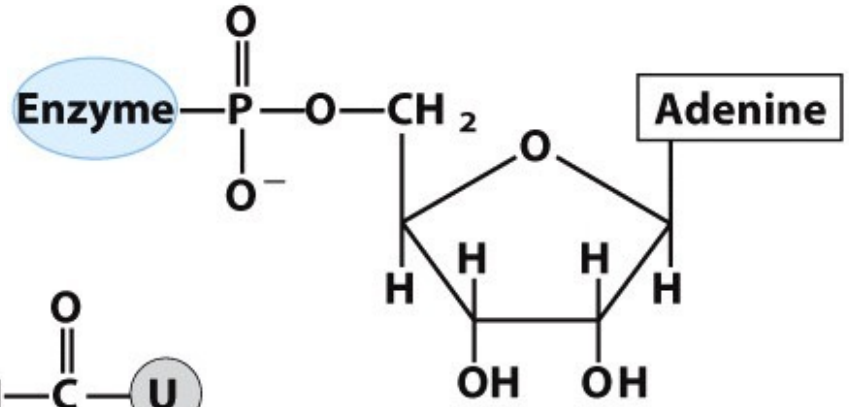


Reversible Covalent Modification

- Simple modifications:
  - Methylation (Lys, Arg).
  - Acetylation (Lys, α-amino).
  - **Phosphorylation (Ser, Thr, Tyr).**

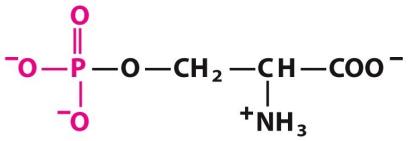


- More complex modifications:
  - Adenylylation.
  - ADP-ribosylation.
  - Ubiquitination.

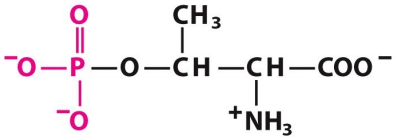


Phosphorylation and Dephosphorylation

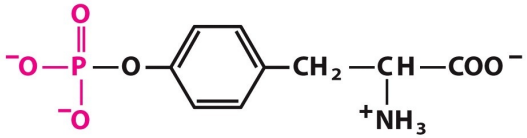
- Phosphorylation.
  - Catalyzed by protein kinase.
  - Transfer of phosphoryl group from ATP to a residue on protein.
  - Moderately polar -> bulky and charged.
- Dephosphorylation.
  - Catalyzed by protein phosphatase.
  - Produces a phosphate ion and a free -OH group.



Phosphoserine



Phosphothreonine



Phosphotyrosine

Regulation by Phosphorylation

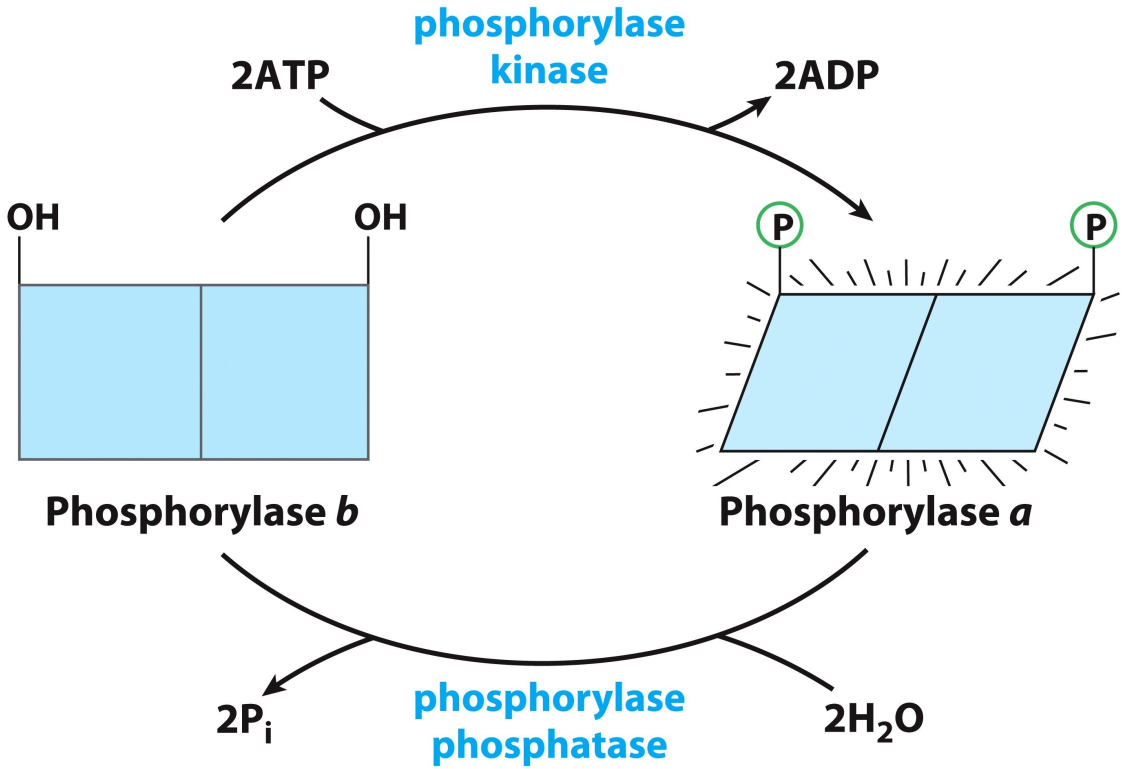
- Glycogen phosphorylase
  - Catalyze following reaction.

$$(\text{glucose})_n + P_i \longrightarrow (\text{glucose})_{n-1} + \text{glucose 1-phosphate}$$

glycogen — shortened glycogen chain

  - NOT a kinase.
  - Not use ATP as phosphoryl donor.
- Glycogen phosphorylase occurs in two forms.
  - More active phosphorylase a, two Ser residues phosphorylated.
  - Less active phosphorylase b, two Ser residues dephosphorylated.

Glycogen Phosphorylase Regulation

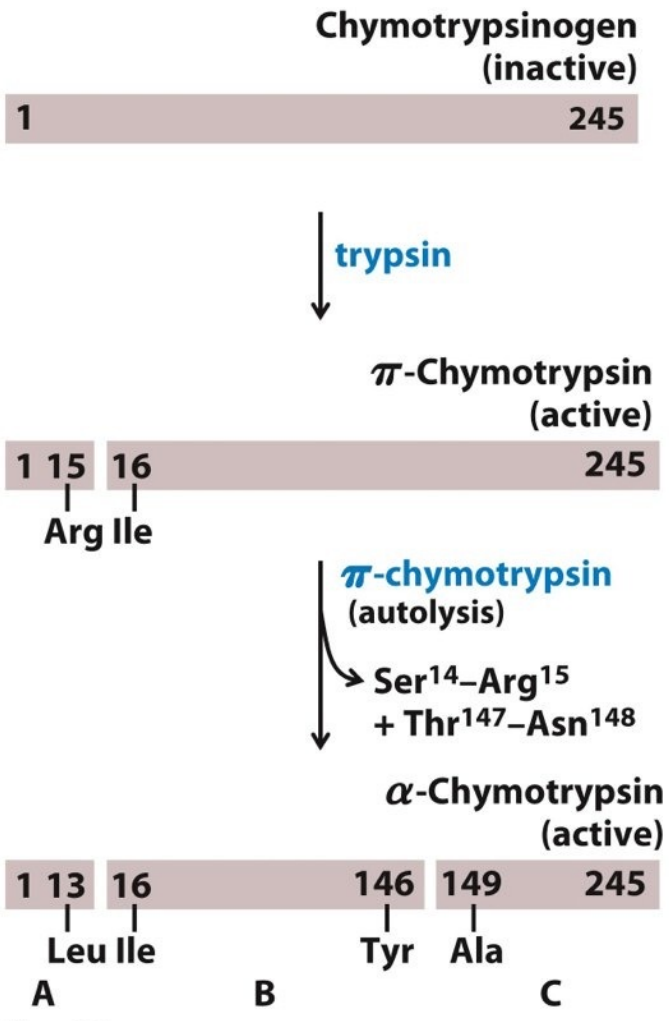


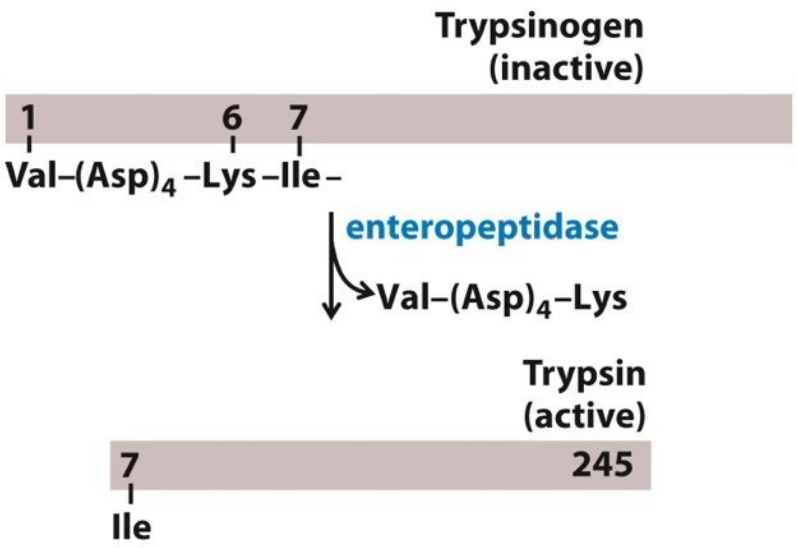
- Phosphorylation catalyzed by phosphorylase kinase
- Dephosphorylation catalyzed by phosphorylase phosphatase

Regulation by Proteolytic Cleavage

- Some enzymes are first synthesized as an inactive precursor.
  - Inactive precursor called **zymogen or proenzyme**.
  - Chymotrypsin initially synthesized as chymotrypsinogen.
  - Trypsin initially synthesized as trypsinogen.
- Specific cleavage causes conformational change.
  - Enzyme active site exposed.
  - Irreversible activation.

Activation of Zymogens





In final active forms, some residues are missing.

Summary 6.5 Regulatory Enzymes

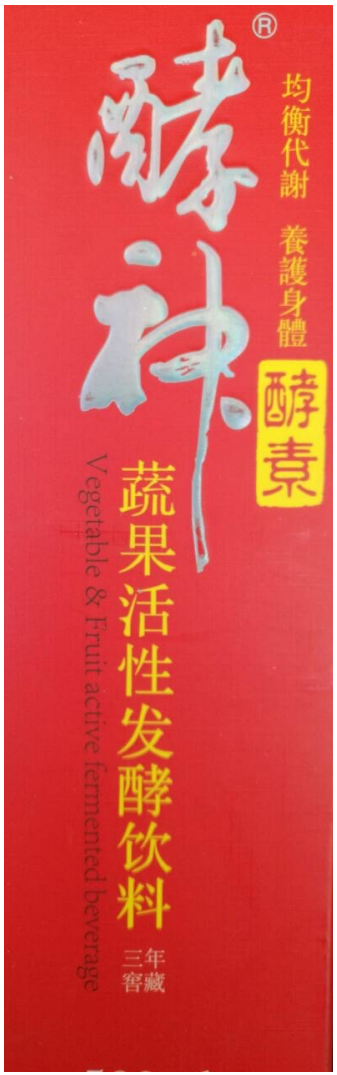
- Allosteric enzyme is regulated by reversible binding of a modulator to a regulatory site. The effect may be inhibitory or stimulatory.
- Regulatory enzymes can be modulated by covalent modification. Phosphorylation is a common way to regulate enzyme activity.
- Many proteases are synthesized as inactive zymogens, and are then activated by proteolytic cleavage.

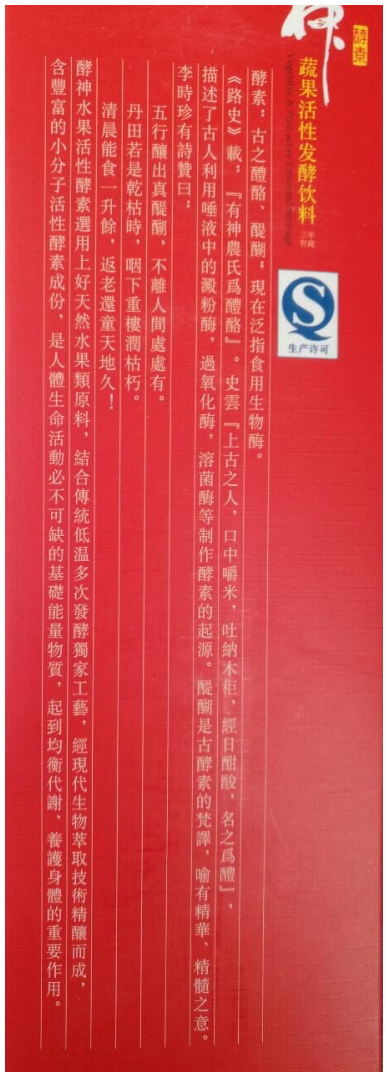
Chapter 6 Summary

In this chapter, we learned:

- why nature needs enzyme catalysis
- how enzymes can accelerate chemical reactions
- how to perform and analyze kinetic studies
- how chymotrypsin breaks down peptide bonds
- how enzyme activity can be regulated

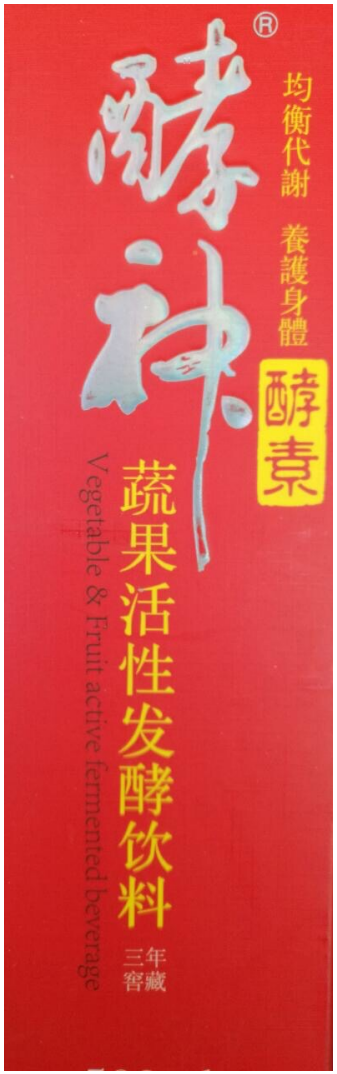
酵素 = 酶 = Enzyme

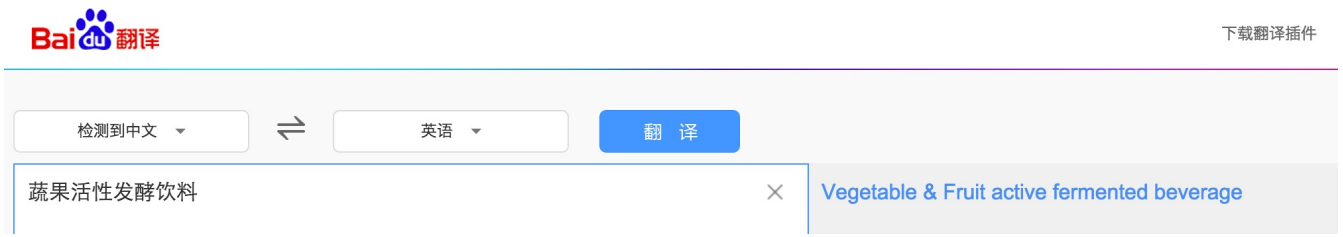

酵神
酵素
均衡代謝 養護身體
蔬果活性发酵饮料
Vegetable & Fruit active fermented beverage
三年窖藏


酵神
蔬果活性发酵饮料
生产许可
酵素：古之體酪、醍醐，現在泛指食用生物酶。
《路史》載，『有神農氏爲體酪』。史雲『上古之人，口中嚼米，吐納本秬，經日酣酸，名之爲體』，描述了古人利用唾液中的澱粉酶，過氧化酶，溶菌酶等制作酵素的起源。醍醐是古酵素的梵譯，喻有精華、精髓之意。
李時珍有詩贊曰：
五行釀出真醍醐，不離人間處處有。
丹田若是乾枯時，咽下重樓潤枯朽。
清晨能食一升餘，返老還童天地久！
酵神水果活性酵素選用上好天然水果類原料，結合傳統低溫多次發酵獨家工藝，經現代生物萃取技術精釀而成，含豐富的小分子活性酵素成份，是人體生命活動必不可缺的基礎能量物質，起到均衡代謝、養護身體的重要作用。


酵神
蔬果活性发酵饮料
品名：蔬果活性發酵飲料
原料：蔬菜、水果、菇類、植物草本等六十種以上新鮮植物
食用方法：每次30~50ml，每日2~3次
保存期限：24個月
生產日期：見瓶身
保存條件：常温避光
2015/07/13
净含量：500ml
生產許可證編號：QS3707060154 88
標准編號：Q/BSDS0001S-2013
营养成分表
项目 每100克 NRV%
能量/Energy 767千焦 9%
蛋白质/Protein 0 0
脂肪/Fat 0 0
碳水化合物/Total Carbohydrate 45.1克 15%
钠/Sodium 0 0

酵素可以通过发酵得到吗？



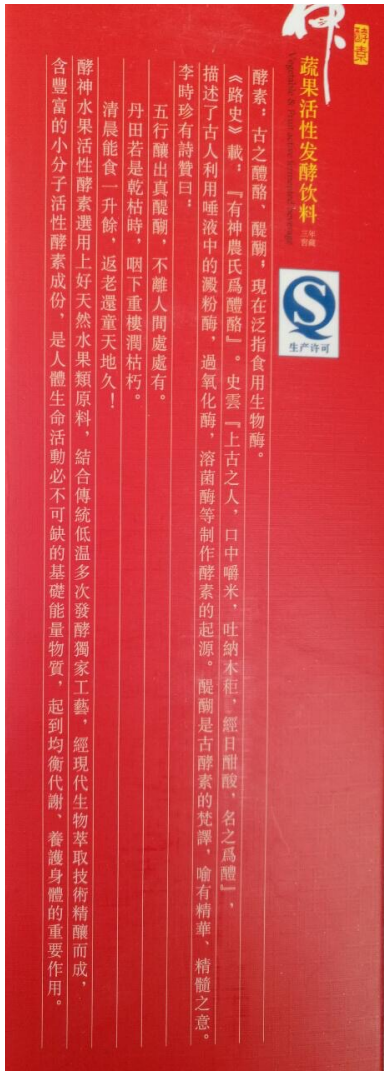


蔬果活性发酵饮料
Vegetable & Fruit active fermented beverage

Fermentation in yeast and bacteria is a metabolic process that converts sugar to acids or alcohol.
Lactic acid fermentation in oxygen-starved muscle cell

Produce lactic acid to preserve food.
　pickled cucumber, kimchi and yogurt 腌黄瓜、泡菜、酸奶
Produce alcoholic beverage
　wine and beer 白酒、红酒、啤酒

酵素在中国古代就有？



“酵素，古之醴酪、醍醐；**现在泛指食用生物酶**。”

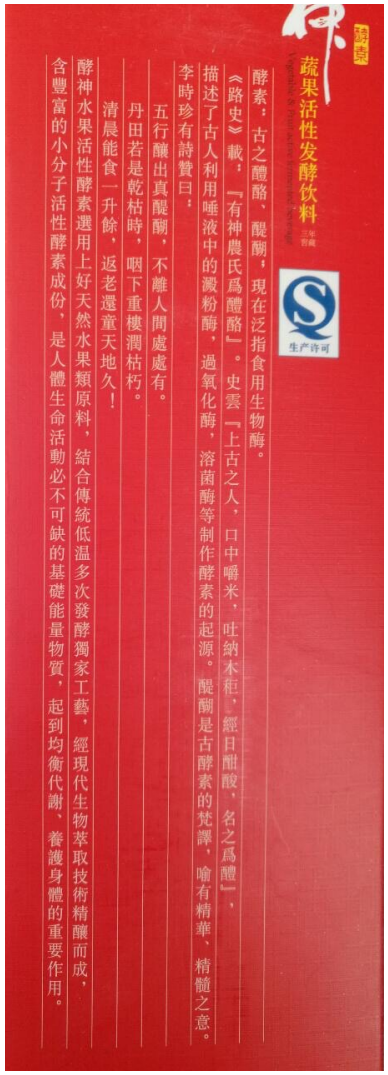
醴酪[lǐ lào]：

1. 以麦芽糖调制的杏仁麦粥；
2. 谷物（所含的碳水化合物）经蒸煮、发酵等步骤而制得的酒；
3. “浆液甘酸如醴酪。”——唐朝白居易《荔枝图序》

醍醐[tí hú]：

1. 由奶提炼出来的酥油，呈油脂状；
2. “做酪时，上一重凝者为酥，酥上如油者为醍醐。”——明朝李时珍《本草纲目》

通过发酵得到的是酵素吗？



“酵神水果活性酵素选用上好天然水果类原料，结合传统低温多次发酵独家工艺，经现代生物萃取技术精酿而成，含丰富的小分子活性酵素成份，是人体生命活动必不可缺的基础能量物质。”

发酵是把各种果蔬放在一起，给予适当的温度湿度，让果蔬中自带的一类微生物——比如乳酸菌——发生代谢反应，分解果蔬中的蛋白质和糖类等生物大分子，最后生成氨基酸，乳酸，维生素等营养物质。直白地说发酵就和腌泡菜一个原理。发酵过程中，酶并没有啥特别的，它以一种普通蛋白质的身份、作为一种可被利用的营养源，被微生物快速分解，与所有其它蛋白质无异。一旦被分解，酶就不复存在，因此发酵过后，能残活的酶已非常少，几乎可以忽略不计。简言之，这么多种果蔬被精华提炼之后，成份中已经基本没有酶。也就是说，**“酵素”里面几乎没有“酵素”**。

直接吃酵素有用吗？

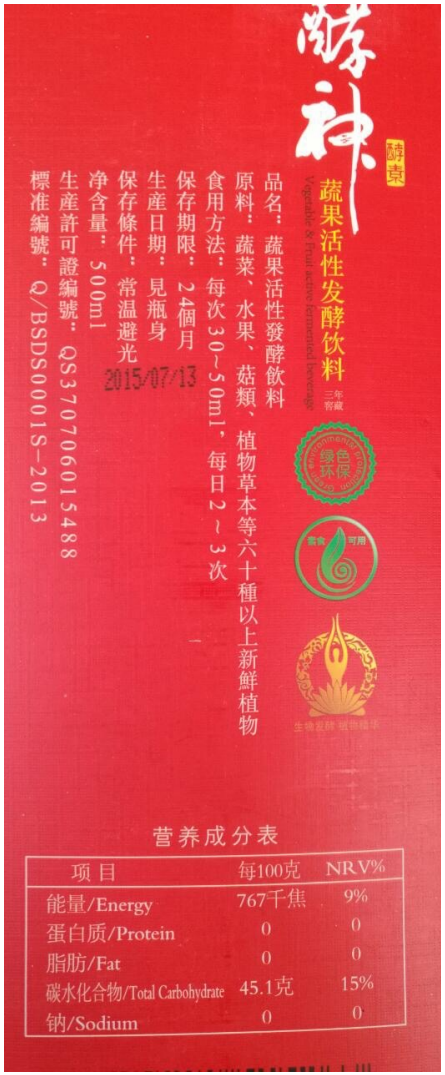
- 人体消化道的每一个组成器官都含有帮助消化的酶。尤其是胃蛋白酶，专门攻击食物中带来的各种蛋白质，在胃中将它们分解消化，胃蛋白酶才不管你是水果酵素还是红烧肥肠。果蔬经历精华提炼后残存下的一点点酶，作为蛋白质进入人体后，也难逃被消化道蛋白酶分解的厄运。

- 我们即使假设日本酵素中有超强酶，可以不被分解，人吃了也是没用的。因为每一种酶要想发挥作用，必须得有活性，不然就等同于普通蛋白质。酶要有活性需要特定的温度，酸碱度和作用对象，任何一个条件不满足，酶都不会有功能。在人体消化系统的恶劣环境下，果蔬中带来的酶要么战死于消化道，要么被俘虏捆绑住手脚，没有用武之地也就发挥不了活性，又何谈神奇功效？

厂家商家比你更了解酵素吗？

- 酵素可以使体内的血液呈弱碱性，将酸性体质变为弱碱性。
- 酵素是一种天然的抗生素，大量服用也不会有副作用。有人将唾液涂在伤口上，就是因为唾液中有唾液酵素，对细菌有杀伤作用。
- 酵素有助于胃肠对食物的消化、分解、吸收，所以酵素是人体生命延续与生长不可或缺的重要物质，它参与了人体内上千种以上的化学反应（合成与分解）。例如：胃的消化活动，可使食物与胃液相混合，将食物消化成粥状。食物被分解后，大分子变成小分子，将蛋白质转化为氨基酸，淀粉转化为麦芽糖、葡萄糖，脂肪转化为甘油、脂肪酸。

营养成分表不会骗人



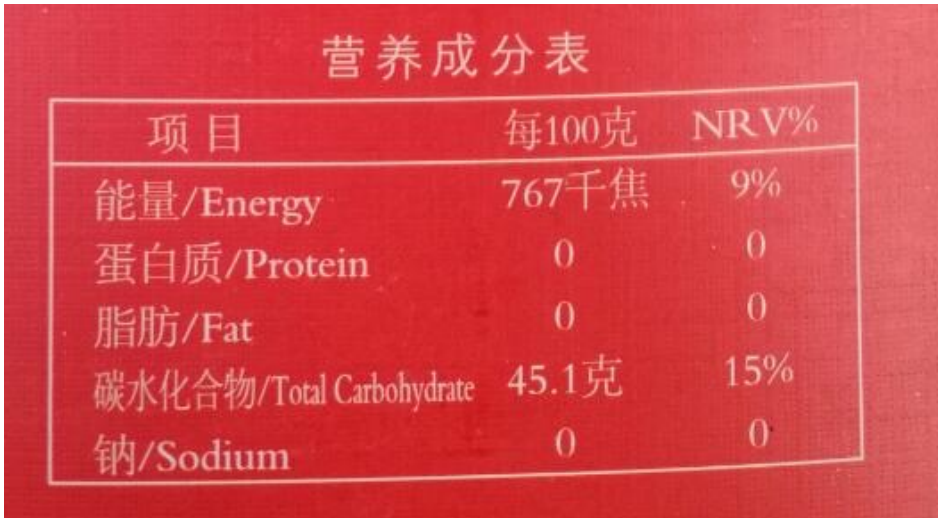
“酵神水果活性酵素选用上好天然水果类原料，结合传统低温多次发酵独家工艺，经现代生物萃取技术精酿而成，含丰富的小分子活性酵素成份，是人体生命活动必不可缺的基础能量物质。”

营养成分表

项目	每100克	NRV%
能量/Energy	767千焦	9%
蛋白质/Protein	0	0
脂肪/Fat	0	0
碳水化合物/Total Carbohydrate	45.1克	15%
钠/Sodium	0	0

蛋白质含量为0，没有酵素
碳水化合物含量为45%，能量来源

酵神酵素与可口可乐的对比



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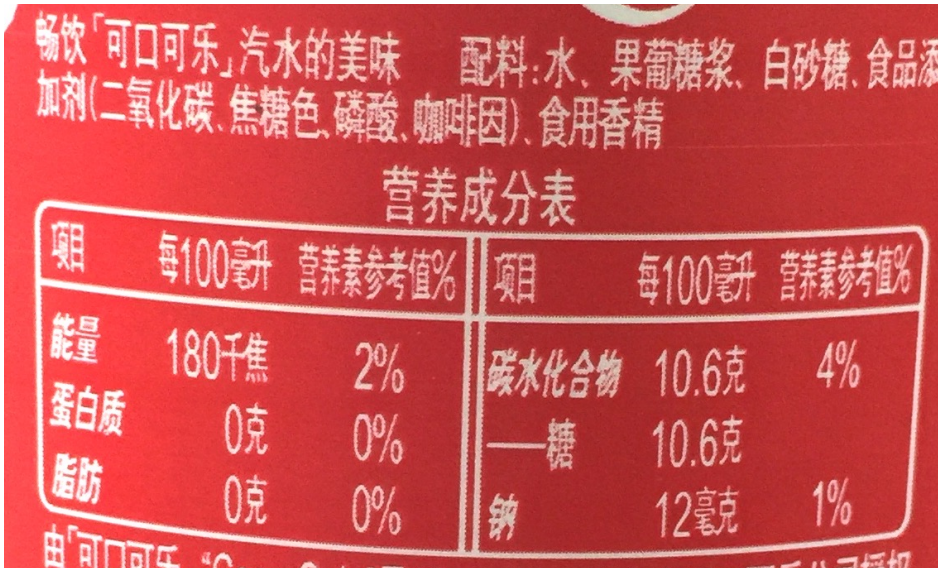

畅饮「可口可乐」汽水的美味　配料:水、果葡糖浆、白砂糖、食品添加剂(二氧化碳、焦糖色、磷酸、咖啡因)、食用香精

营养成分表

项目	每100毫升	营养素参考值%	项目	每100毫升	营养素参考值%
能量	180千焦	2%	碳水化合物	10.6克	4%
蛋白质	0克	0%	—糖	10.6克	
脂肪	0克	0%	钠	12毫克	1%

- 二者的蛋白质与脂肪含量都为0
- 碳水化合物含量
  - 酵神酵素为45%
  - 可口可乐为11%
- 二者的能量来源都是碳水化合物
  - 767千焦 / 45.1克 = 17.0千焦/克
  - 180千焦 / 10.6克 = 17.0千焦/克

下次再有人向你或者你家人推销酵素