From amino acids to proteins

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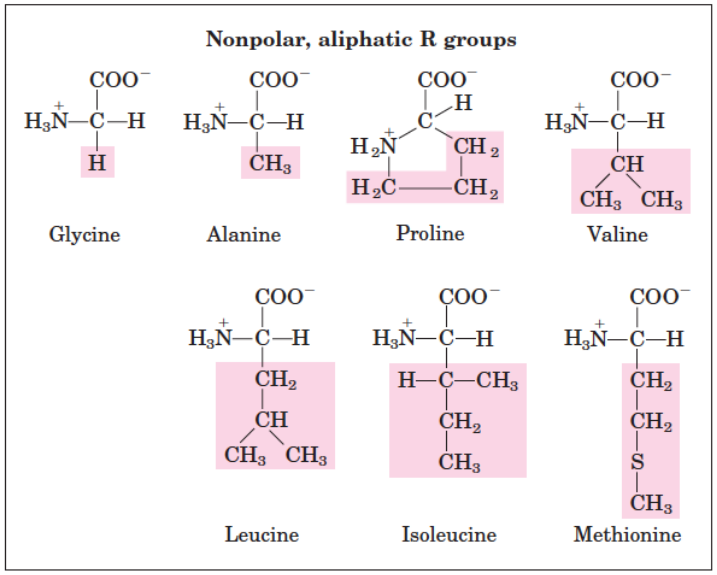
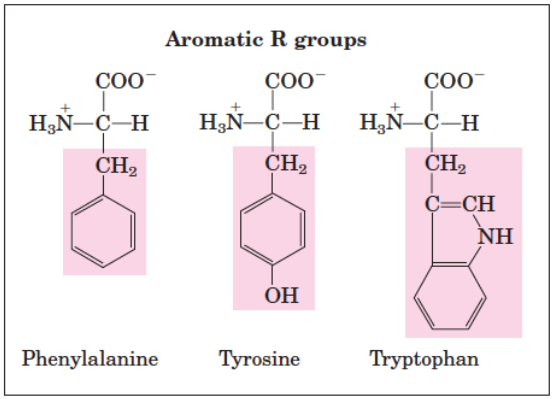
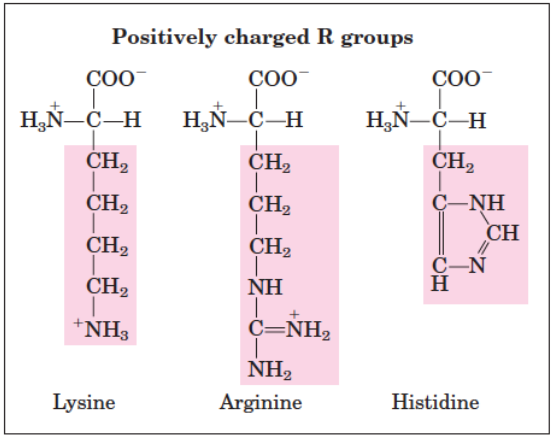
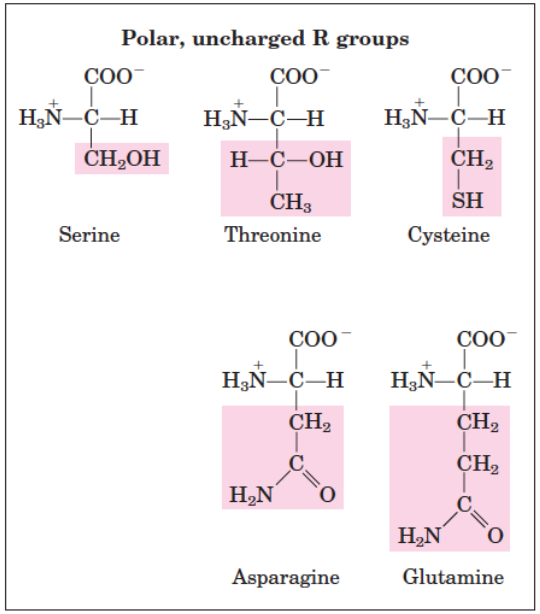
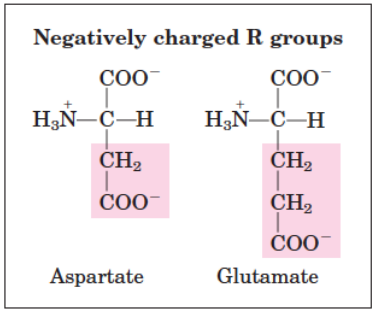
20 common amino acids







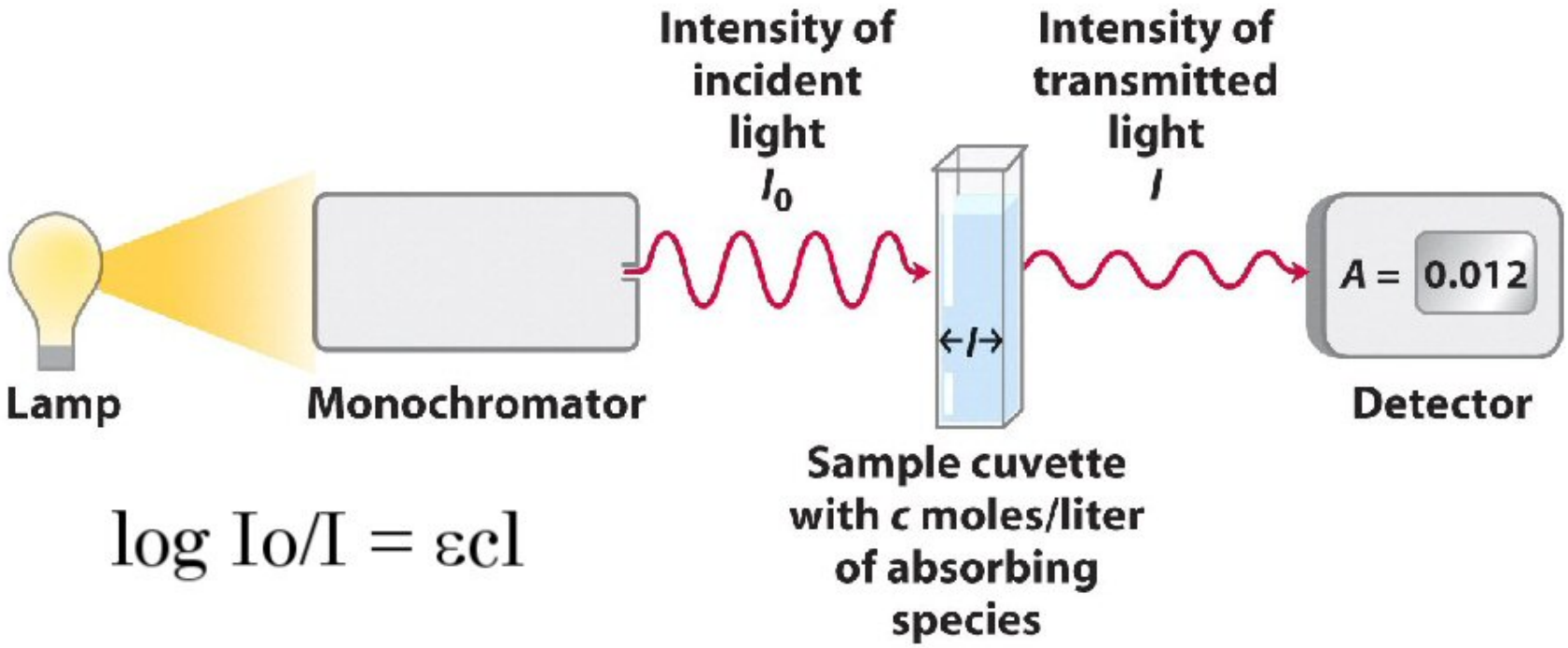




From amino acids to proteins

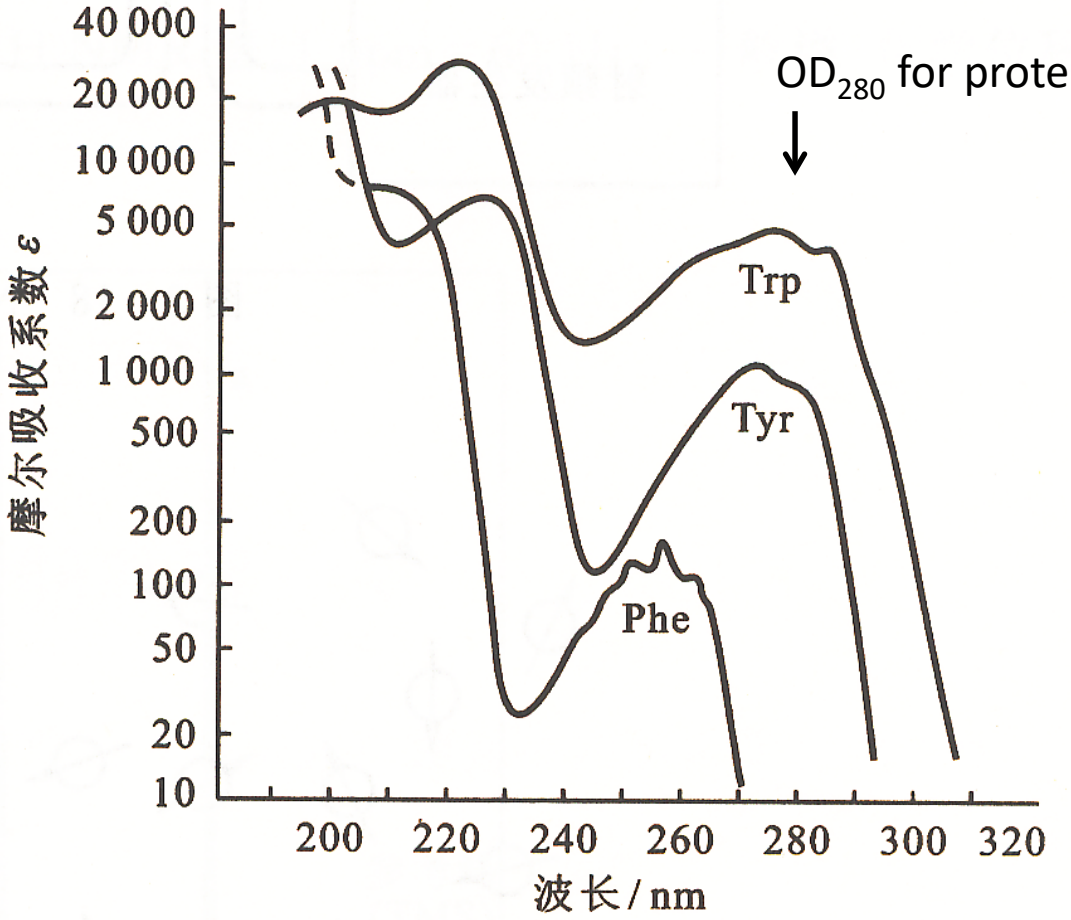
- Explain the optical absorbance（光吸收）;
- Describe the properties of peptide bond（肽键）;
- Interpret the disulfide bond（二硫键）;
- Define the hydrogen bond（氢键）;
- Illustrate the structural basis of α helix.

Optical absorbance（光吸收）
Optical density (OD)（光密度）



$$\log Io/I = \varepsilon cl$$

(Lambert-Beer law)



OD_{280} for protein quantification

图 3－17　芳香族氨基酸在 pH6 时的紫外吸收光谱

等电点 pI （isoelectric point）

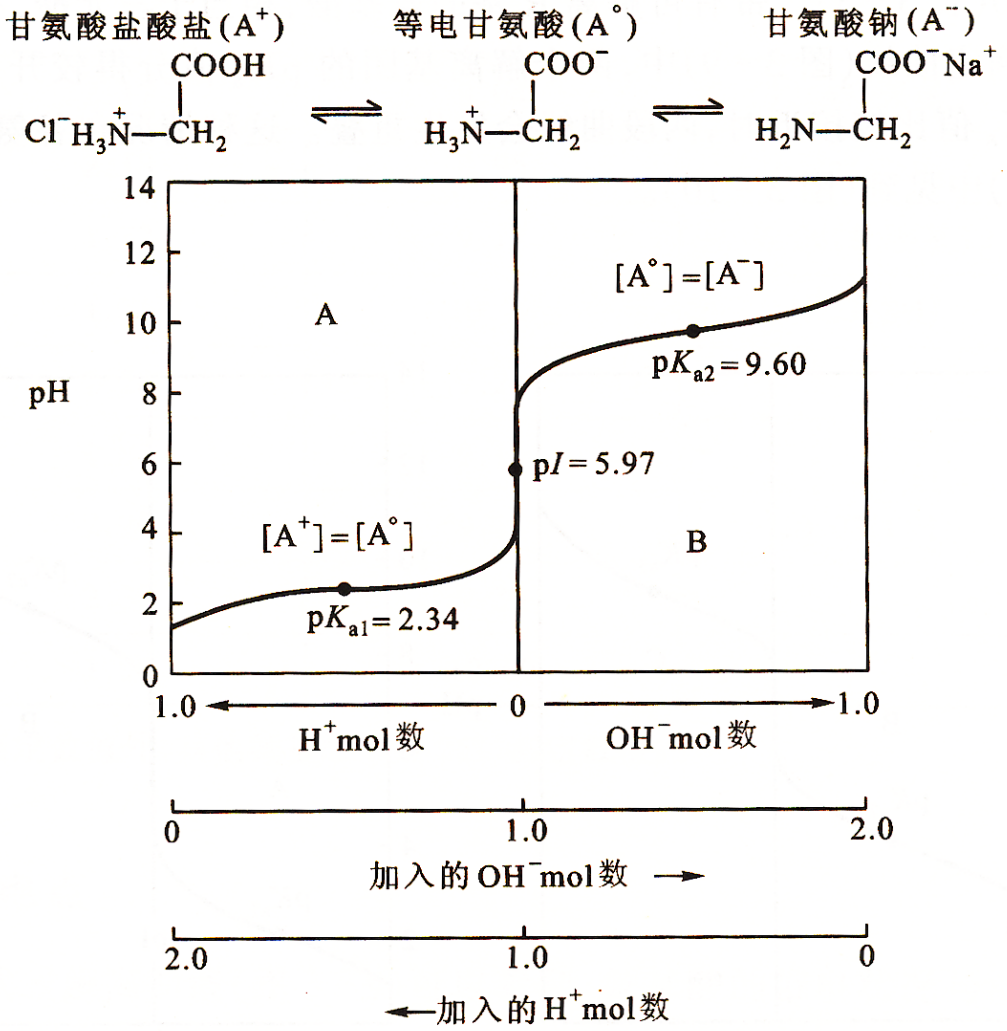


图 3－9　甘氨酸的滴定曲线(解离曲线)

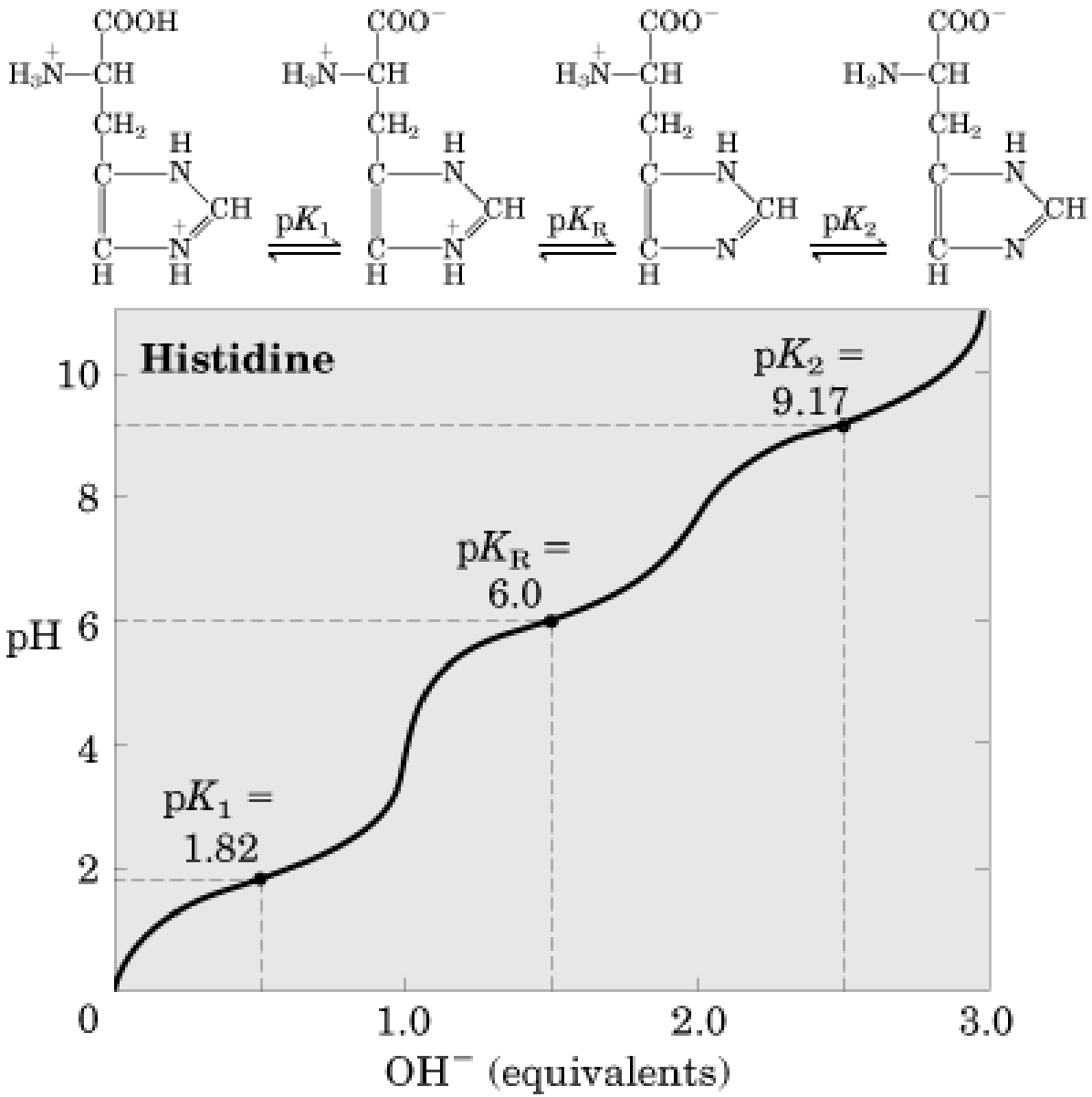
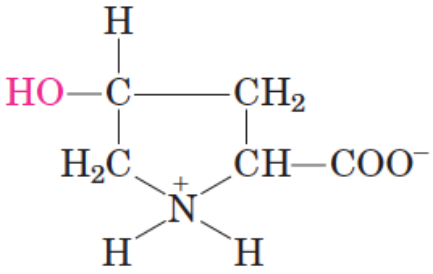

Histidine
pK1 = 1.82
pKR = 6.0
pK2 = 9.17
pH
OH⁻ (equivalents)
0
2
4
6
8
10
1.0
2.0
3.0

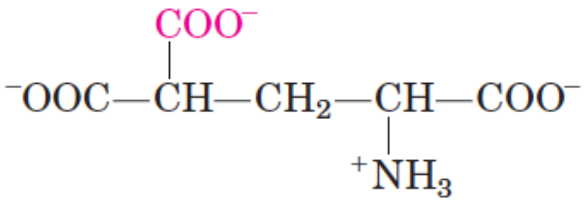
TABLE 3–1 Properties and Conventions Associated with the Common Amino Acids Found in Proteins

Amino acid	Abbreviation/ symbol	M_r	pK_a values: pK_1 (—COOH)	pK_2 ($—NH_3^+$)	pK_R (R group)	pI	Hydropathy index*	Occurrence in proteins (%)†
Nonpolar, aliphatic R groups								
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
Aromatic R groups								
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
Polar, uncharged R groups								
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
Positively charged R groups								
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
Negatively charged R groups								
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

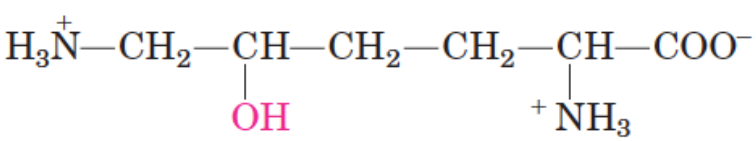
A few examples of other amino acids



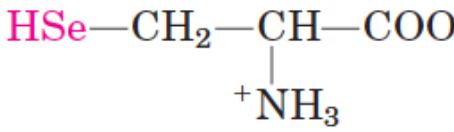
4-Hydroxyproline



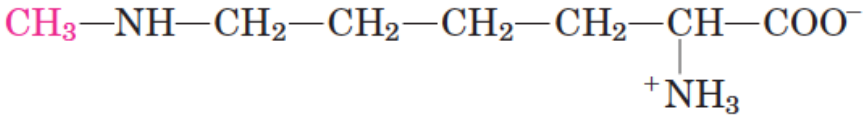
γ-Carboxyglutamate



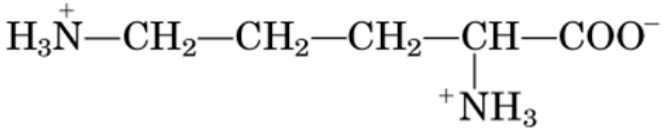
5-Hydroxylysine



Selenocysteine

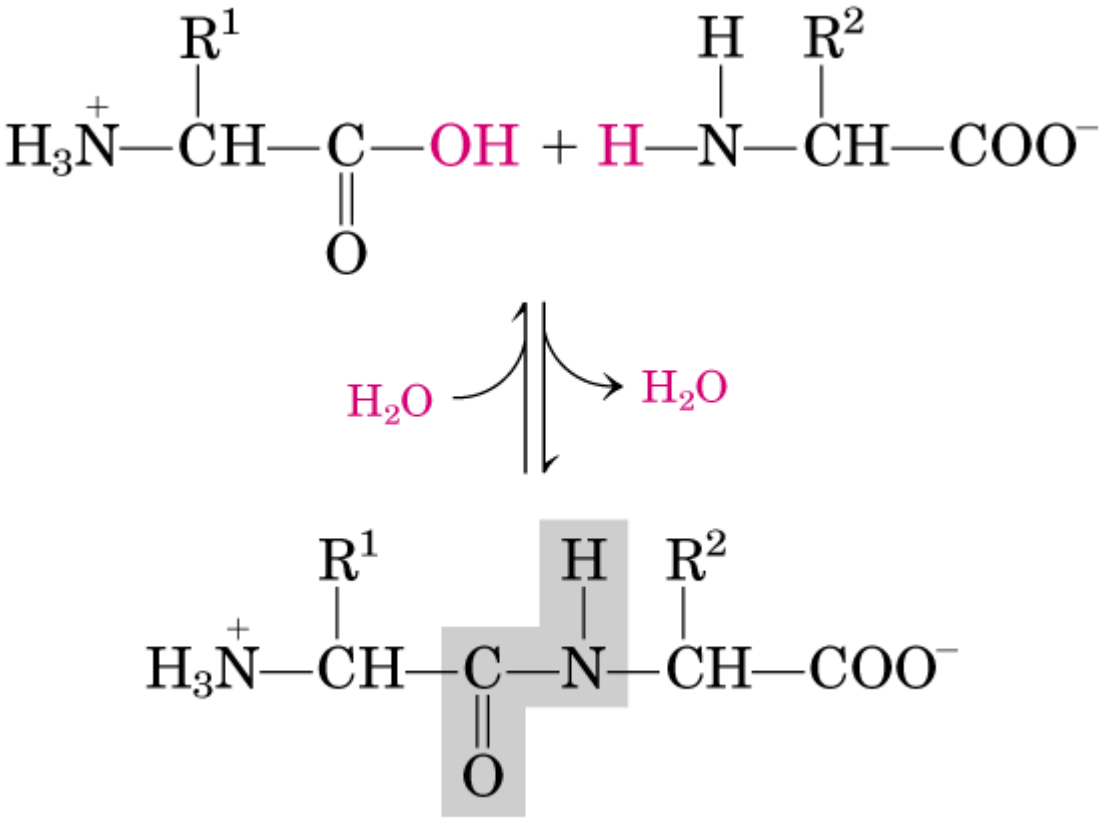


6-*N*-Methyllysine

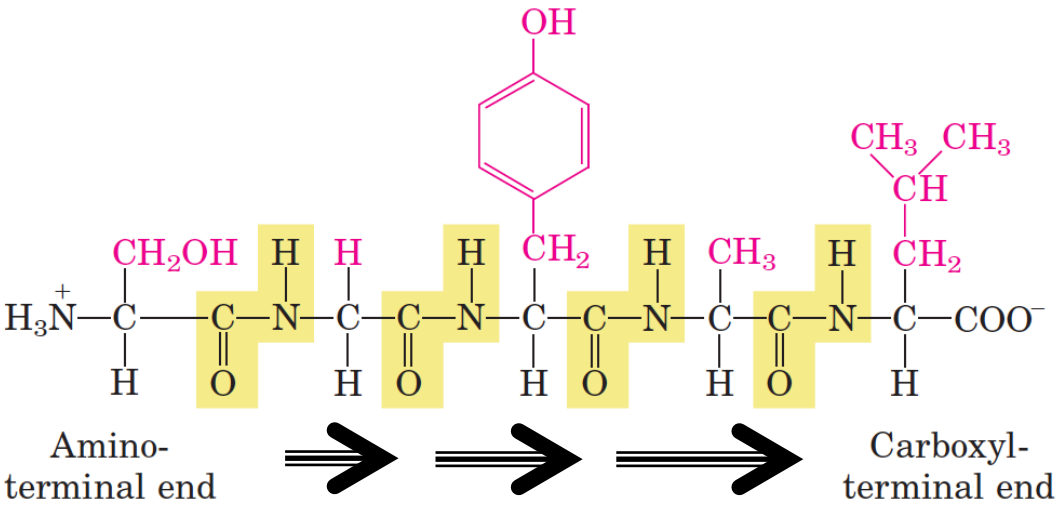


Ornithine

Peptide bond 肽键



Polypeptide chain



side chain

main chain

Ser-Gly-Tyr-Ala-Leu

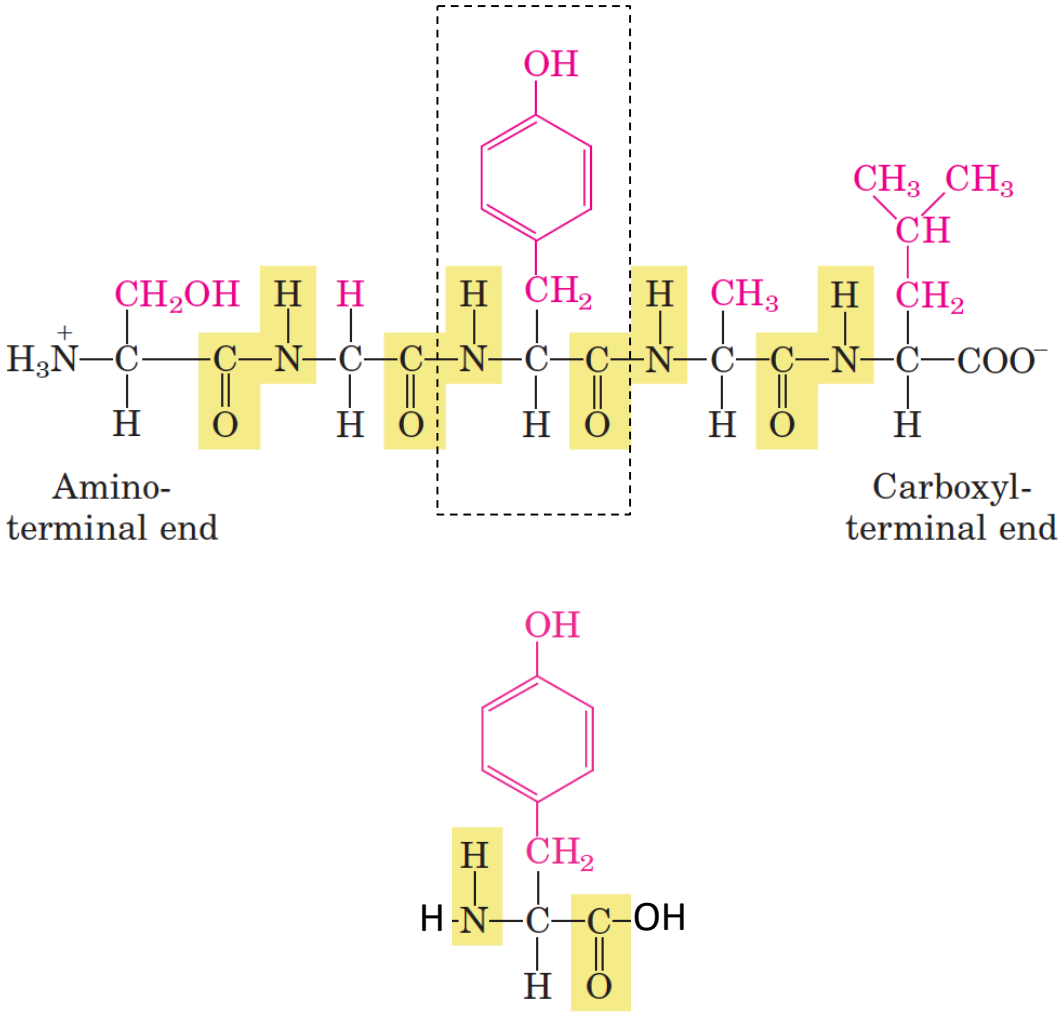
SGYAL

≠

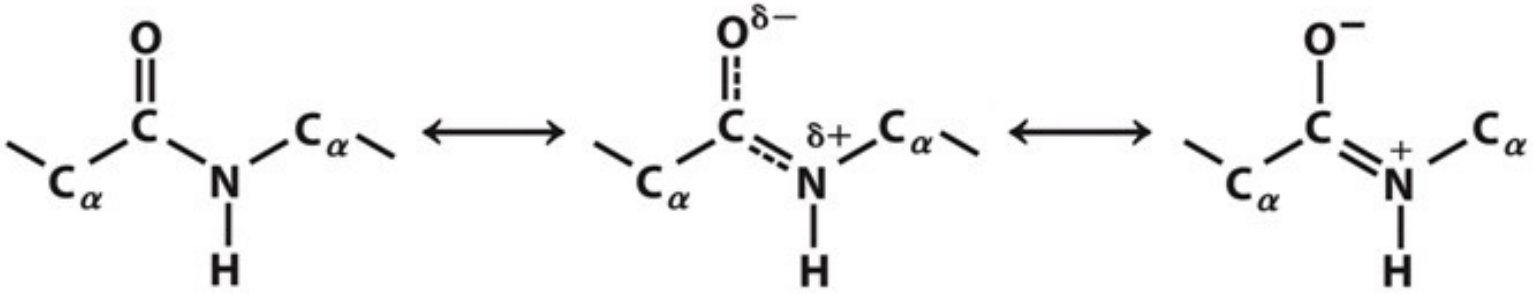
Leu-Ala-Tyr-Gly-Ser

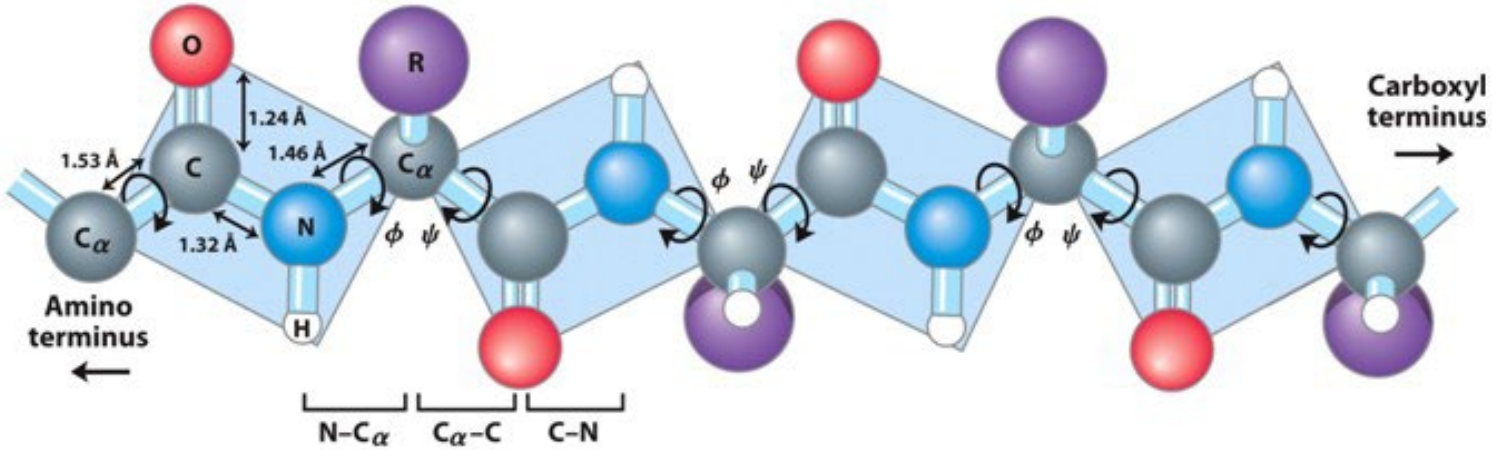
LAYGS

Amino acid *vs.* residue (残基).

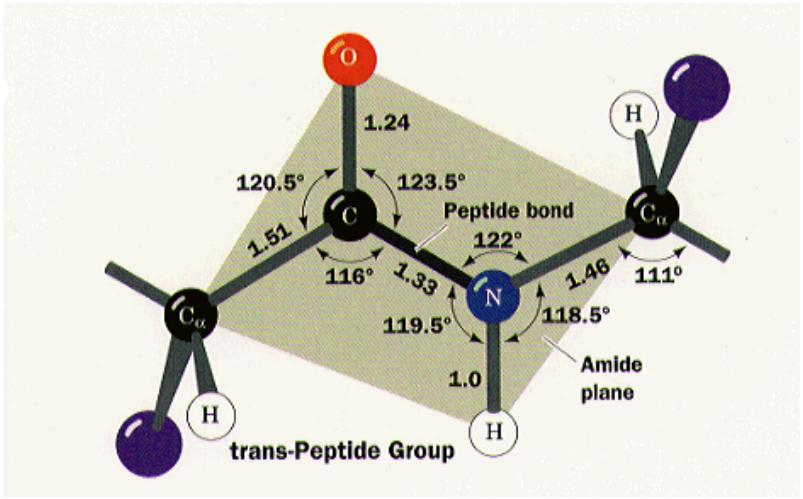


Peptide bond has some double-bond character.





Trans vs. cis configuration （构型）



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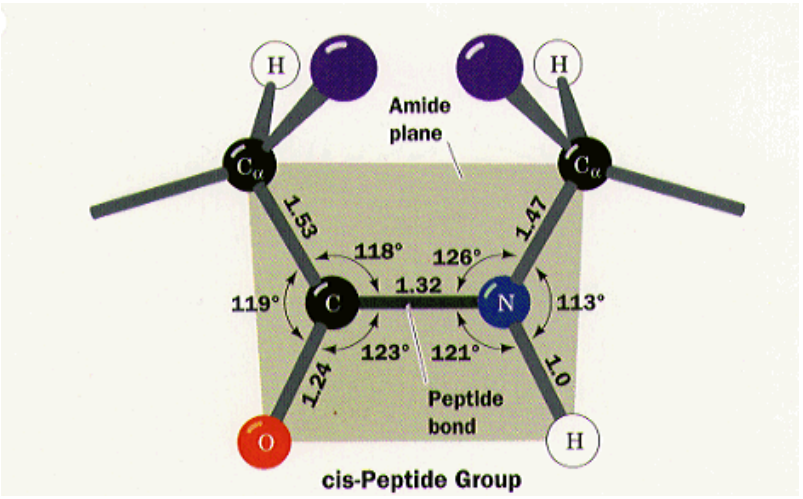

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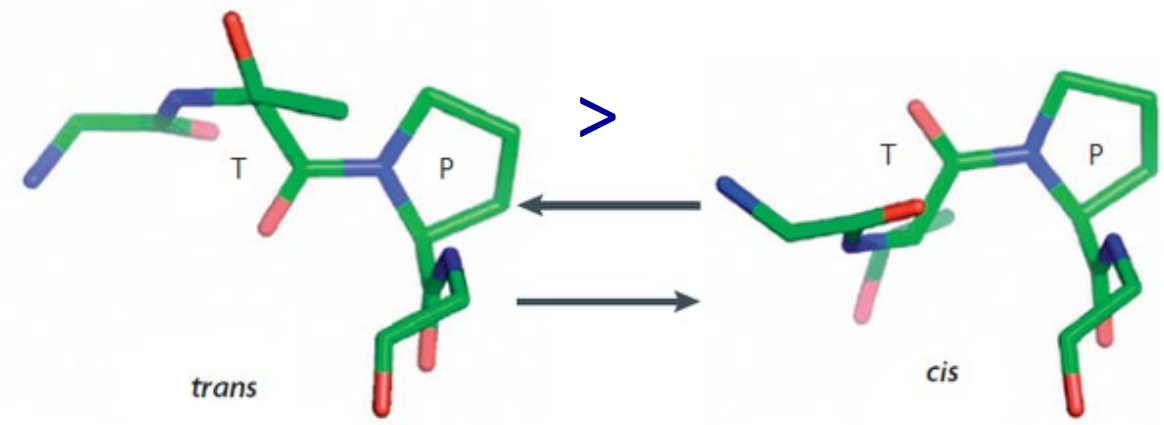
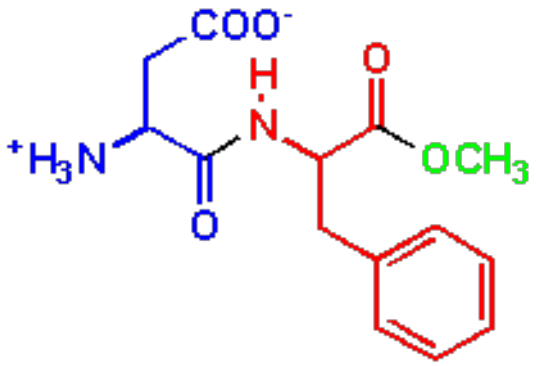


1/10

Some small peptides of physiological interest

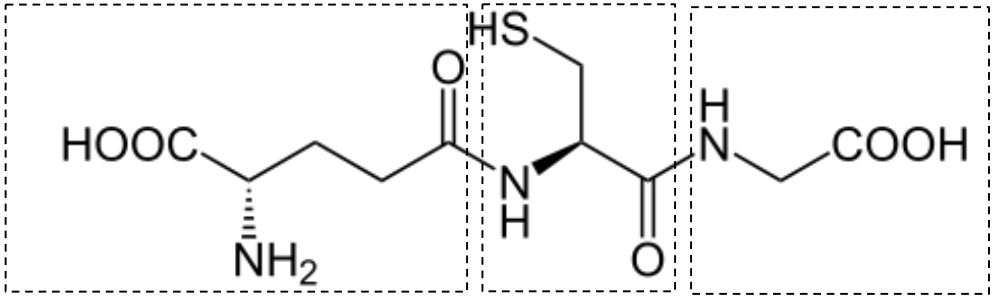
Aspartame: methyl ester derivative of L-Aspartyl-L-phenylalanine; 200x sweeter than sugar.

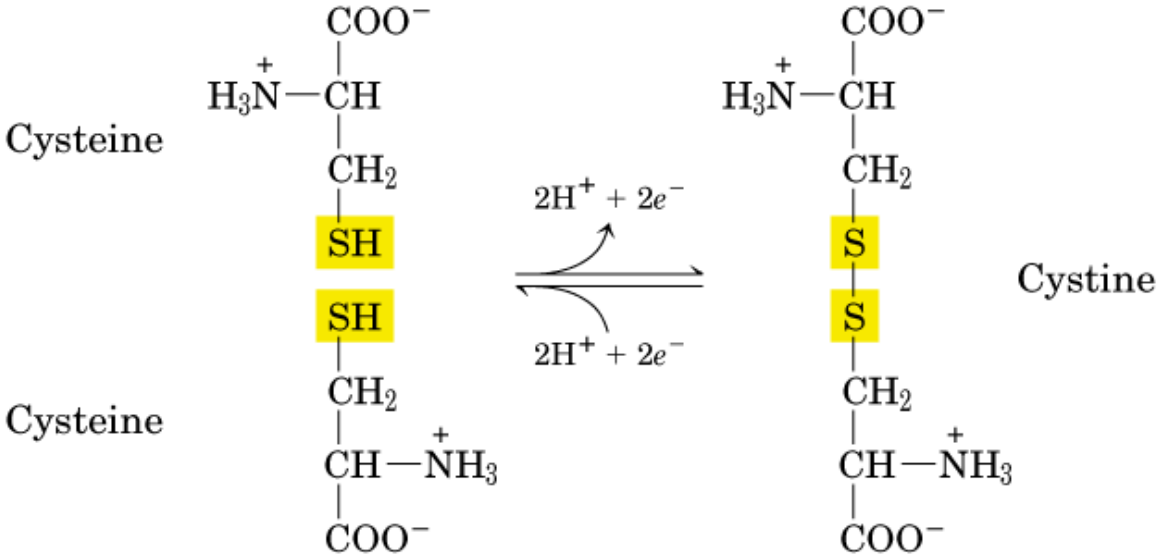


Aspartyl-phenylalanine methyl ester

Some small peptides of physiological interest

Glutathione (GSH)（谷胱甘肽）: tripeptide scavenger of oxidizing agents; oxidized form consists of two glutathione molecules joined by disulfide bridge.





insulin
胰岛素

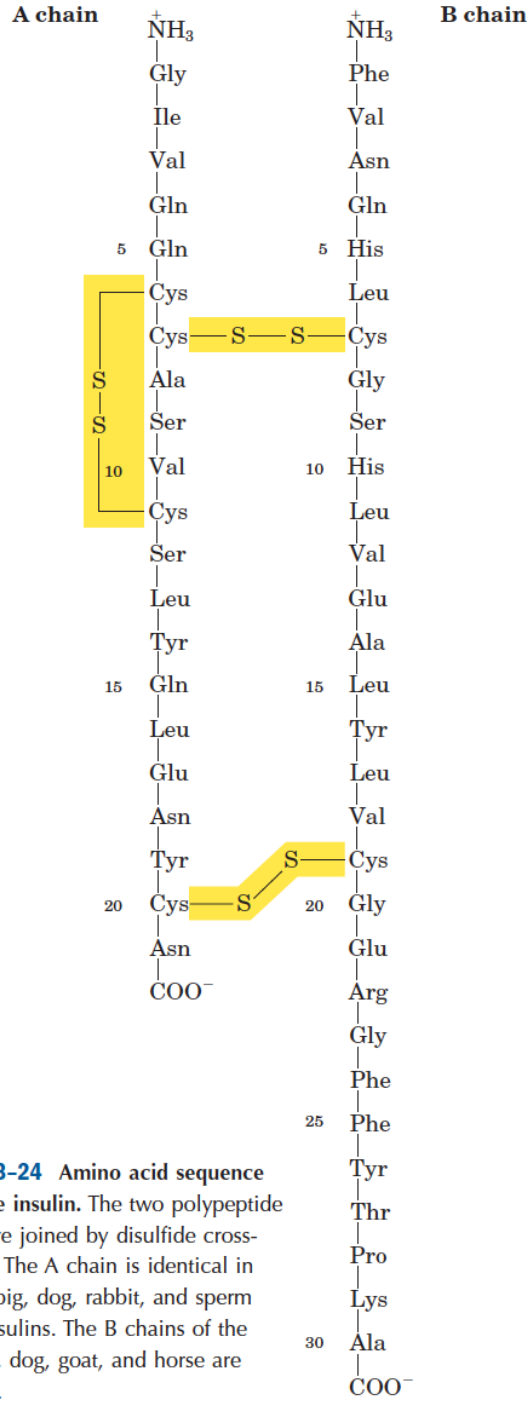
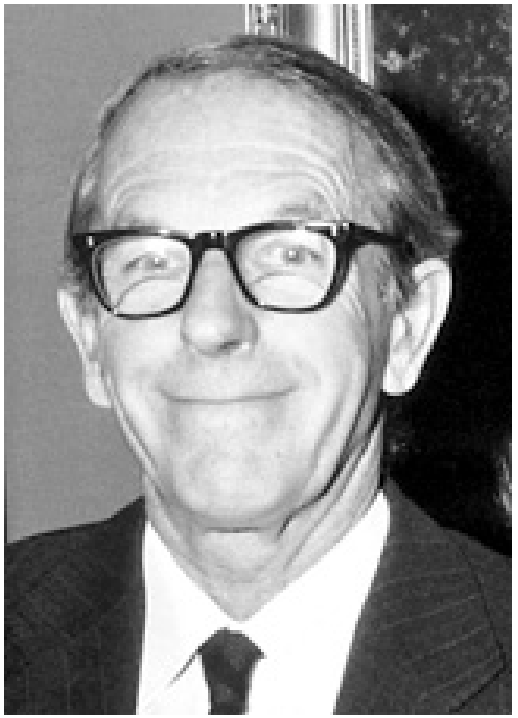


FIGURE 3–24 Amino acid sequence of bovine insulin. The two polypeptide chains are joined by disulfide cross-linkages. The A chain is identical in human, pig, dog, rabbit, and sperm whale insulins. The B chains of the cow, pig, dog, goat, and horse are identical.

Frederick Sanger

The Nobel Prize in Chemistry 1958

"for his work on the structure of proteins, especially that of insulin"



The Nobel Prize in Chemistry 1980

"for their contributions concerning the determination of base sequences in nucleic acids"

我国首次人工合成牛胰岛素


人民日报

我们一定要有无产阶级的雄心壮志，敢于走前人没有走过的道路，敢于攀登前人没有攀登过的高峰。

（《中国共产党第八届中央委员会第十一次全体会议公报》）

1965年9月15日 星期三 第6743号 1965年12月24日 星期六 农历乙巳年十一月十三

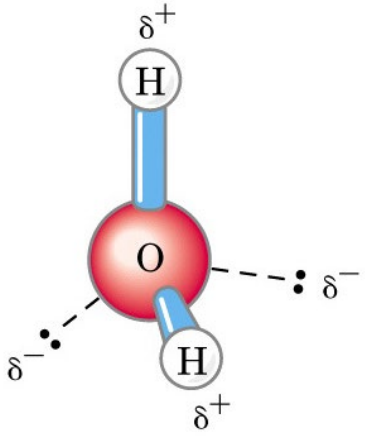
毛泽东思想武装的中国人民有志气有能力攀登前人没有攀登过的高峰

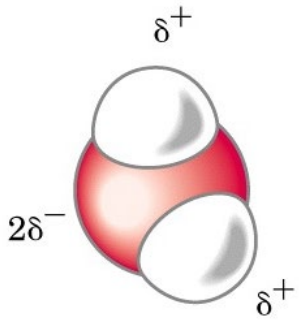
我国在世界上第一次人工合成結晶胰島素

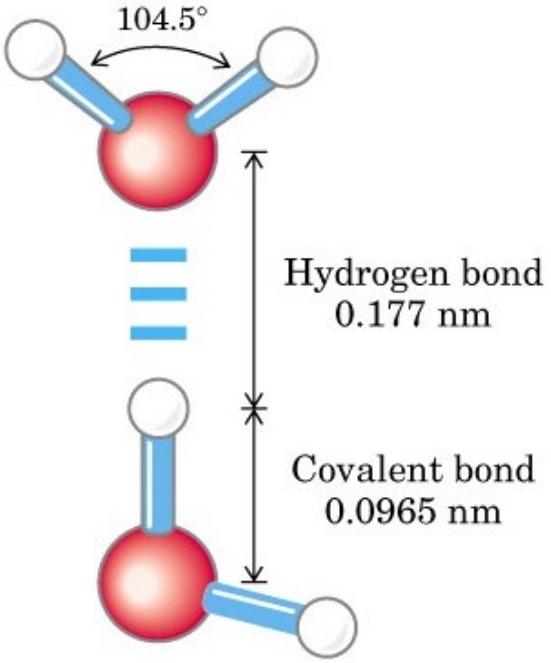
科学工作者在毛泽东思想指导下，经过六年多的艰苦工作，为我国夺得了这项理论科学研究的“世界冠军”。这一杰出的重大成就，标志着人类在揭开生命奥秘的伟大历程中迈进了一大步，为生命起源的唯物辩证学说取得了一项有力的新论据。

胡志明主席写信支持美国人民正义斗争

hydrogen bond （氢键）



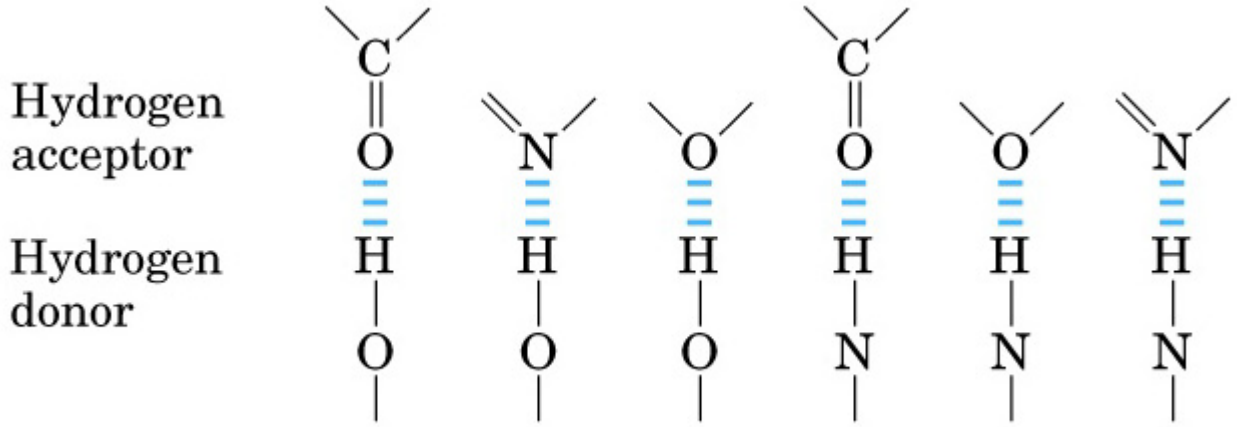




δ: partial （部分的）.

A hydrogen bond is the attractive force between the hydrogen attached to an electronegative atom of one molecule and an electronegative atom of a different molecule.

hydrogen bond （氢键）



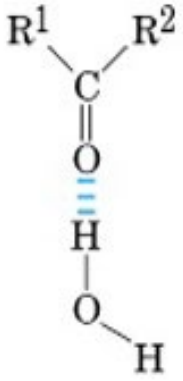
Hydrogen bond ≈ 5% covalent bond （共价键）.

Hydrogen bonds, often in a large amount, make significant contribution for maintaining the protein structure.

Some biologically important hydrogen bonds

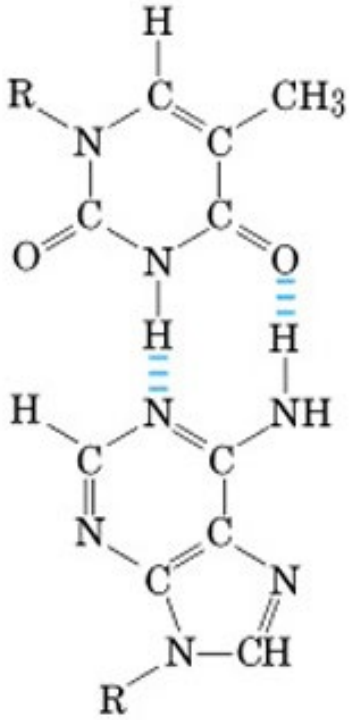
Between the hydroxyl group of an alcohol and water

Between the carbonyl group of a ketone and water



Between peptide groups in polypeptides

Between complementary bases of DNA



Thymine

Adenine

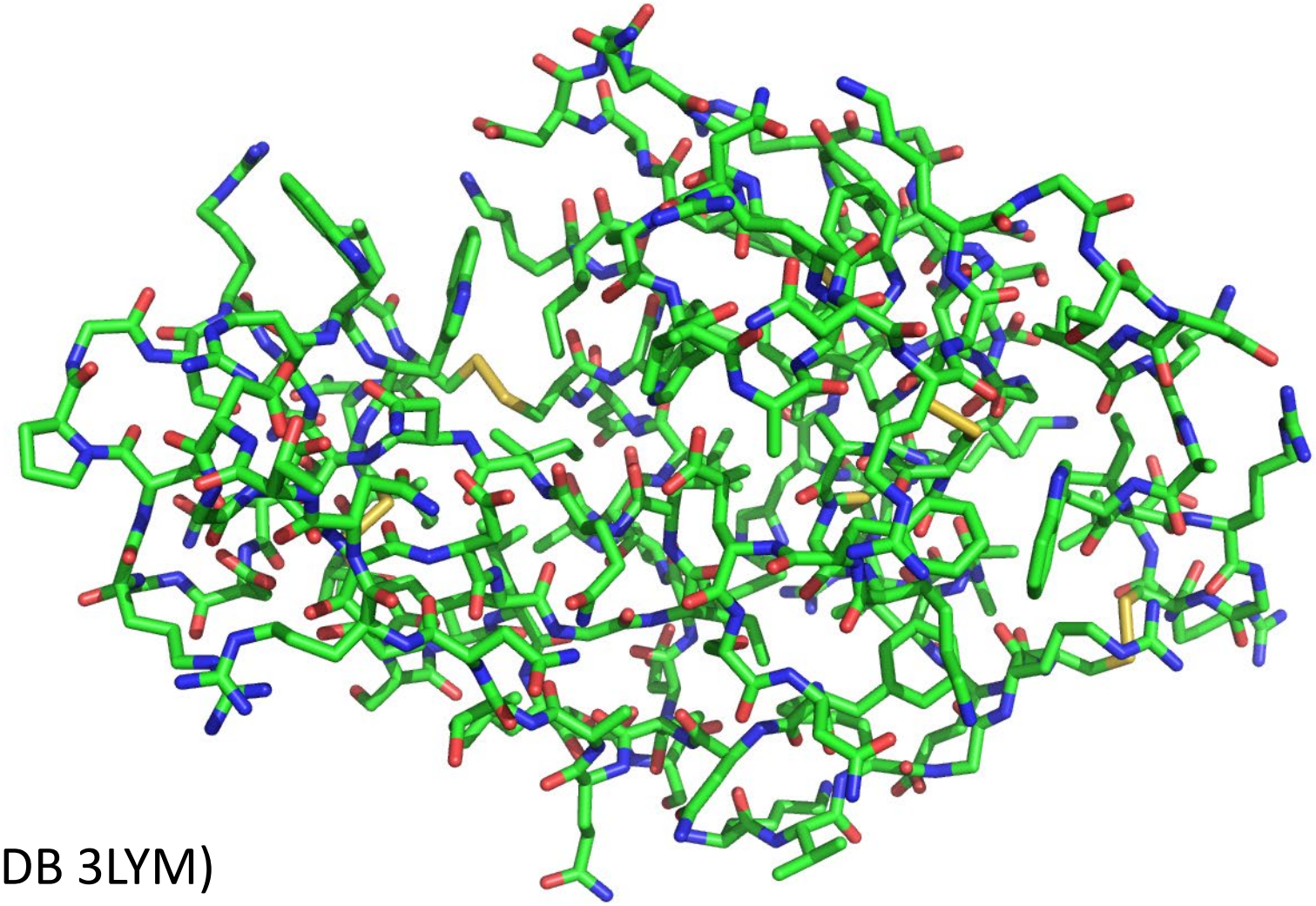
Lysozyme（溶菌酶）as an example

KVFGRCELAAAMKRHGLDNYRGYSLGNWVCAAK
FESNFNTQATNRNTDGSTDYGILQINSRWWCND
GRTPGSRNLCNIPCSALLSSDITASVNCAKKIV
SDGNGMNAWVAWRNRCKGTDVQAWIRGCRL

129 residues;

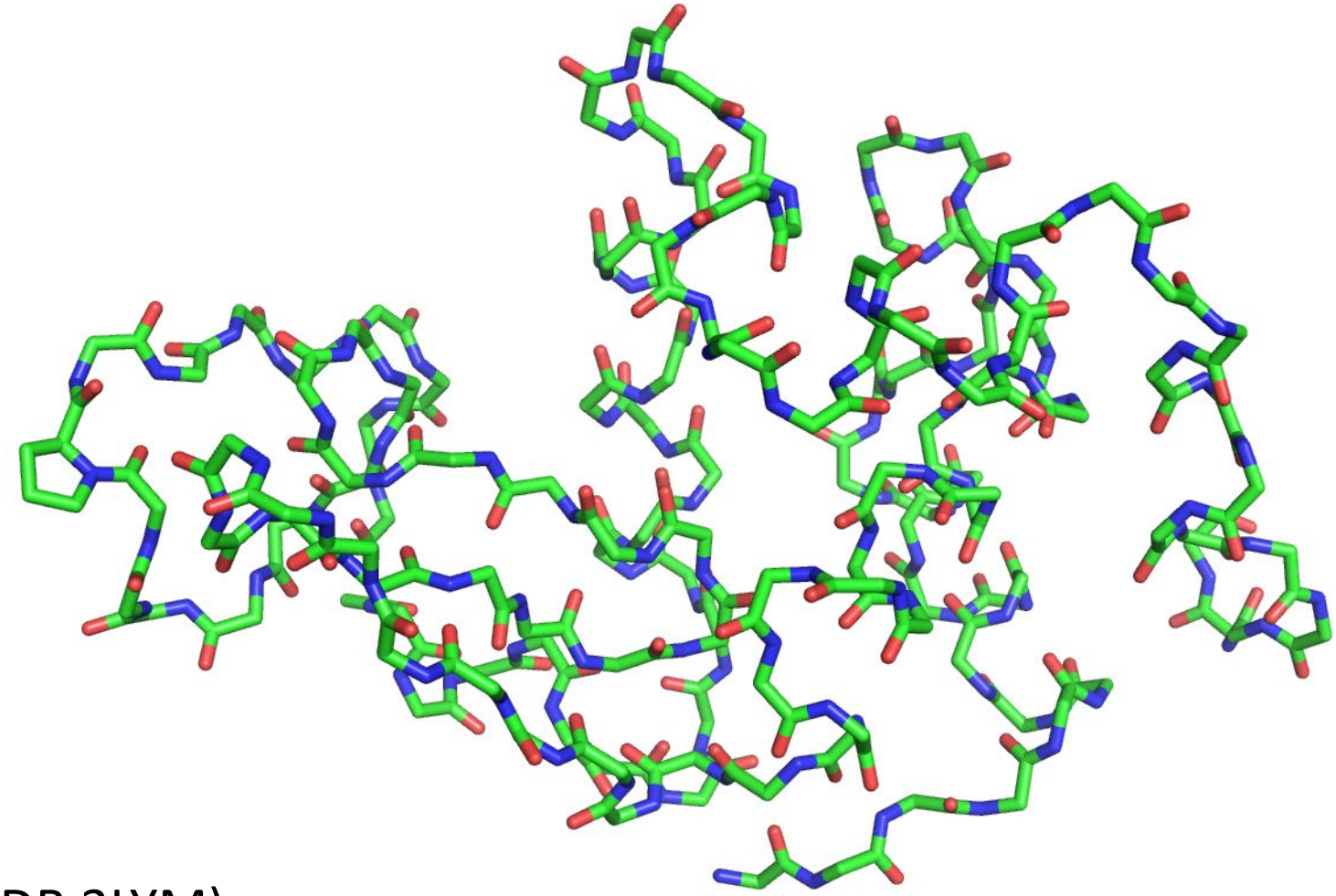
D + E: 9; K + R: 17.

Lysozyme（溶菌酶）as an example



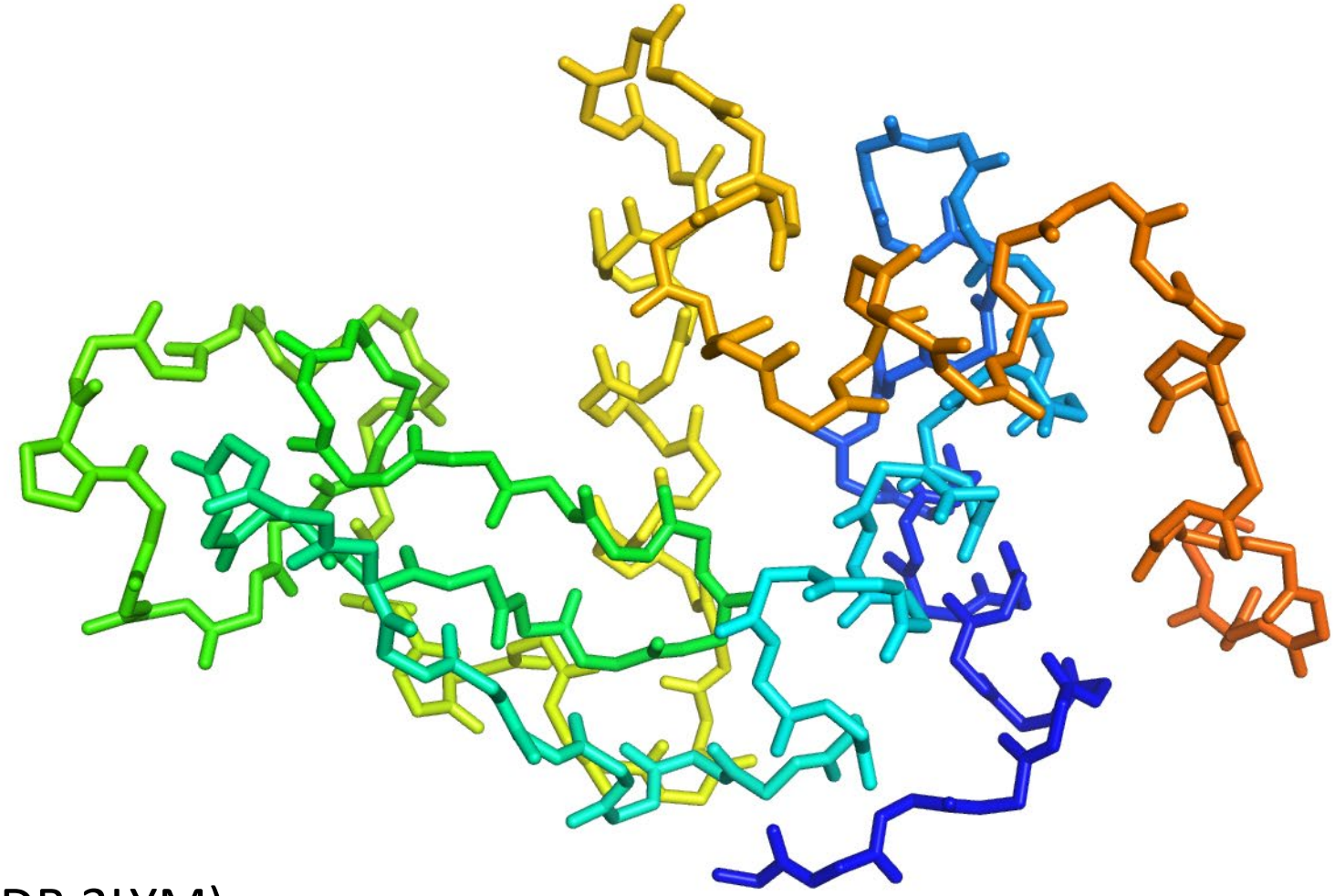
(PDB 3LYM)

Lysozyme（溶菌酶）as an example



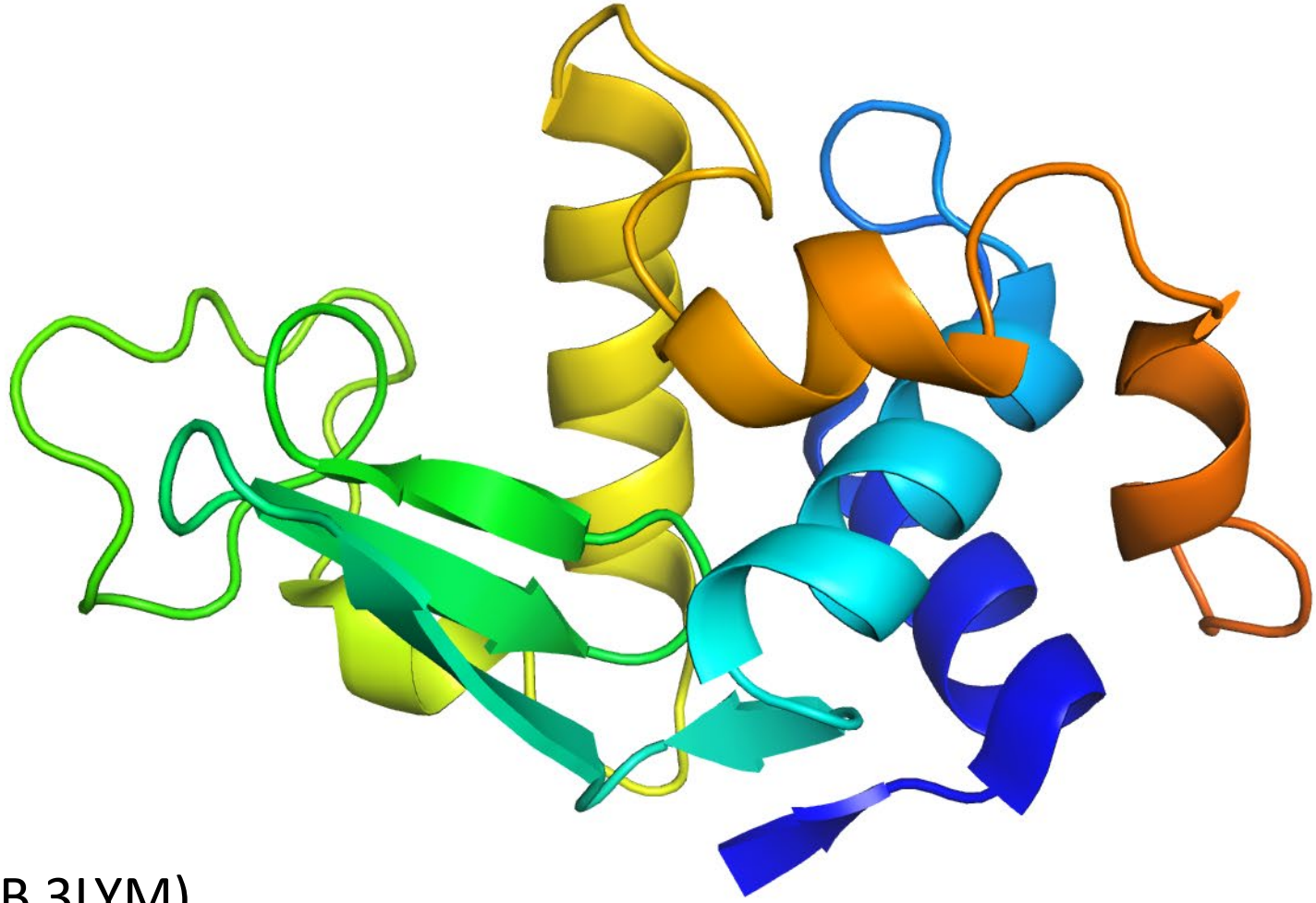
(PDB 3LYM)

Lysozyme（溶菌酶）as an example



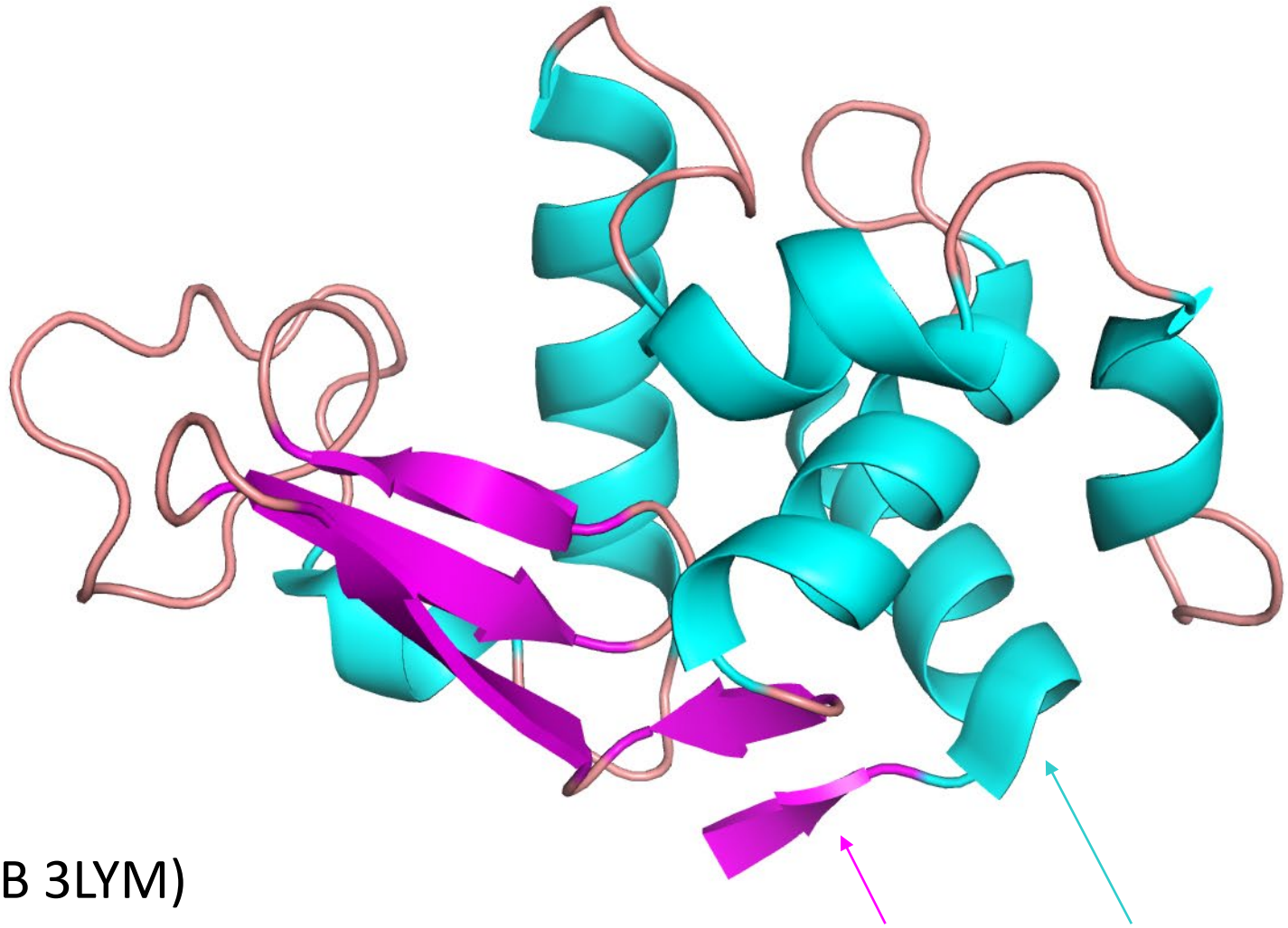
(PDB 3LYM)

Lysozyme（溶菌酶）as an example



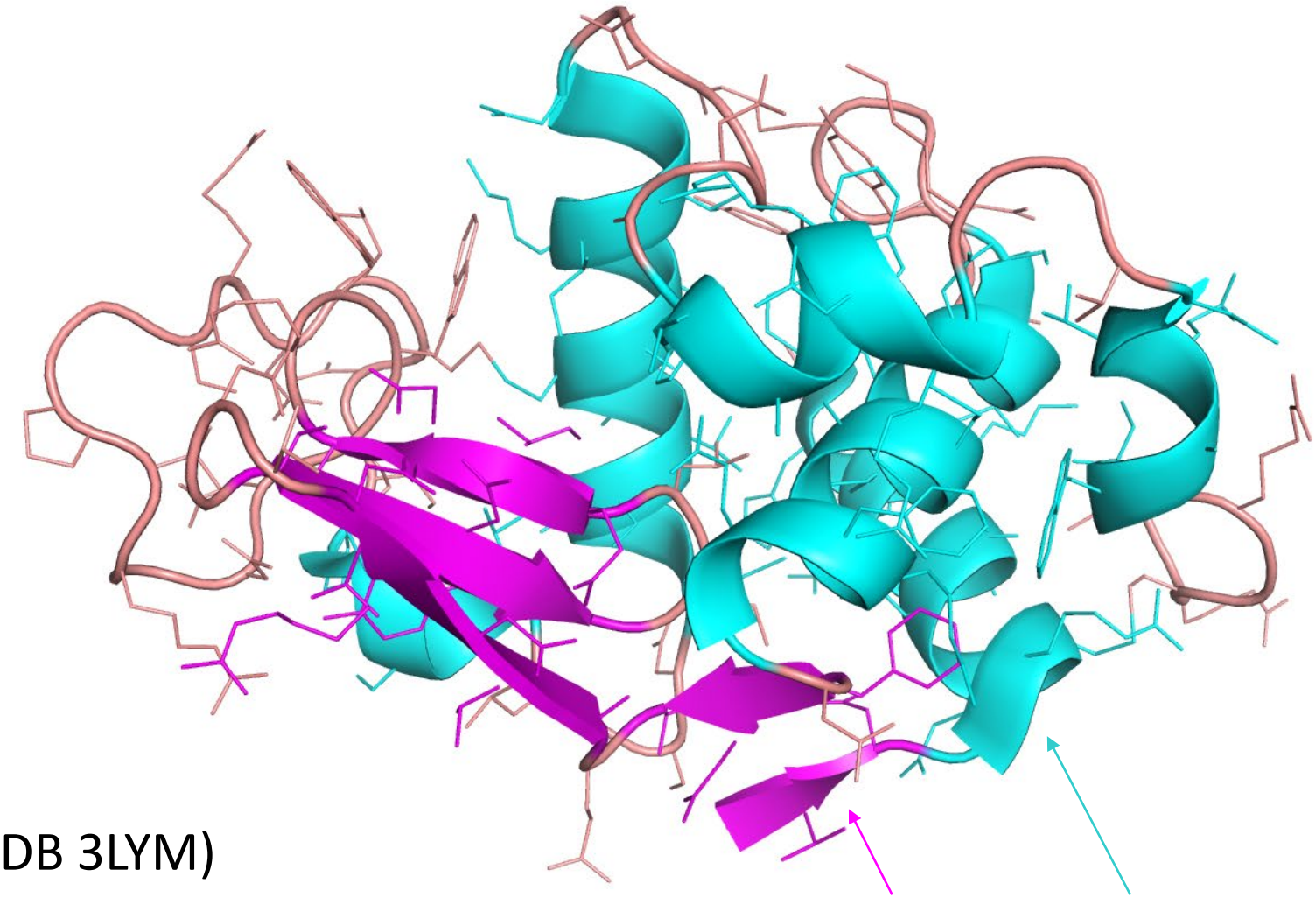
(PDB 3LYM)

Lysozyme（溶菌酶）as an example



(PDB 3LYM)

Lysozyme（溶菌酶）as an example

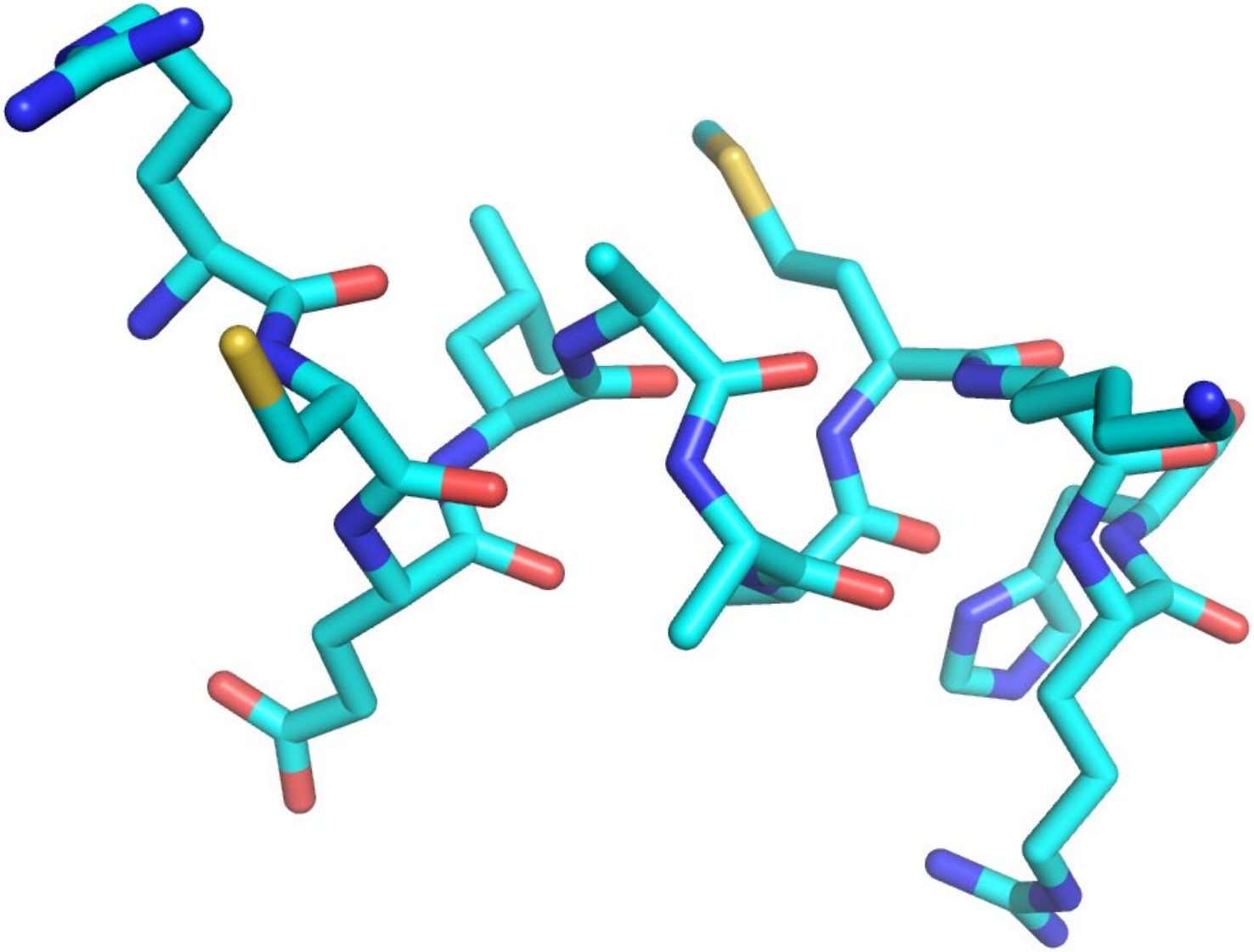


(PDB 3LYM)

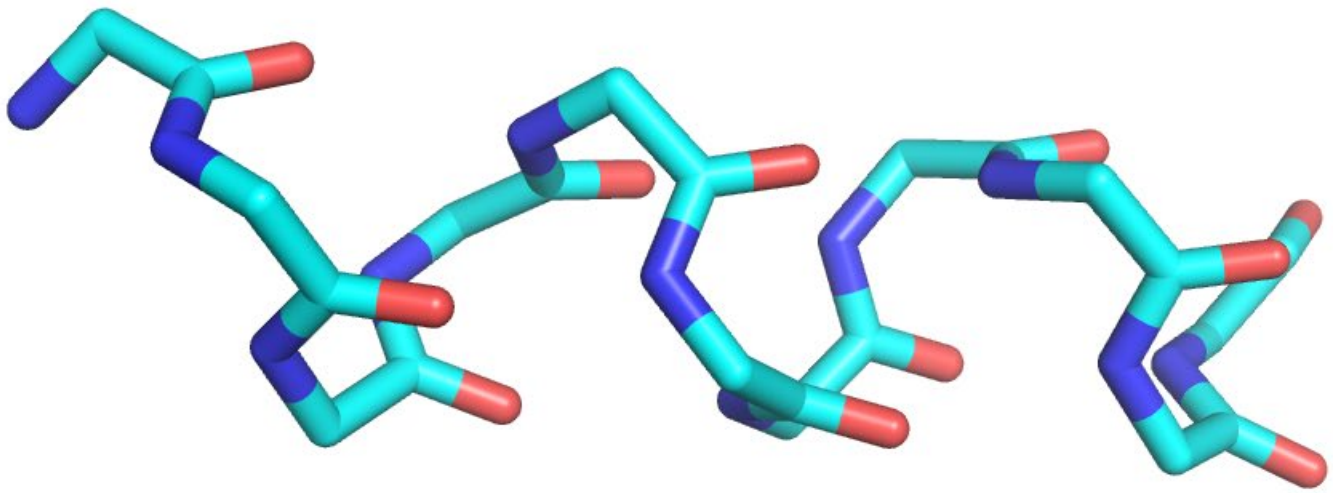
β sheet
(β-折叠)

α helix
(α-螺旋)

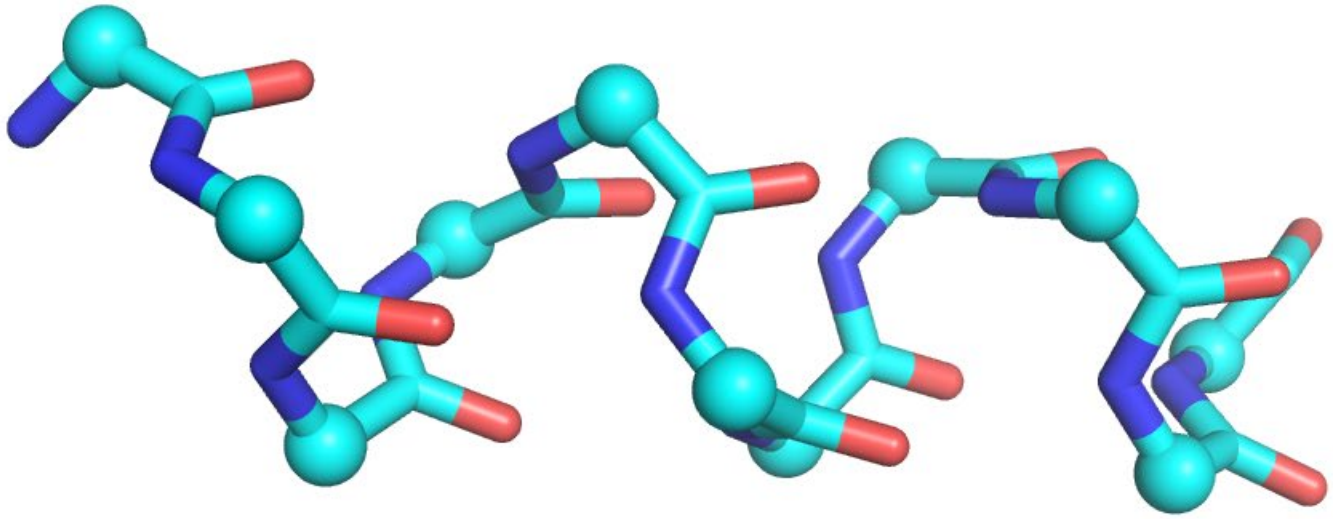
An α-helix in lysozyme: RCELAAAMKRH (color code: CNOS)



An α-helix in lysozyme: RCELAAAMKRH (color code: CNOS)

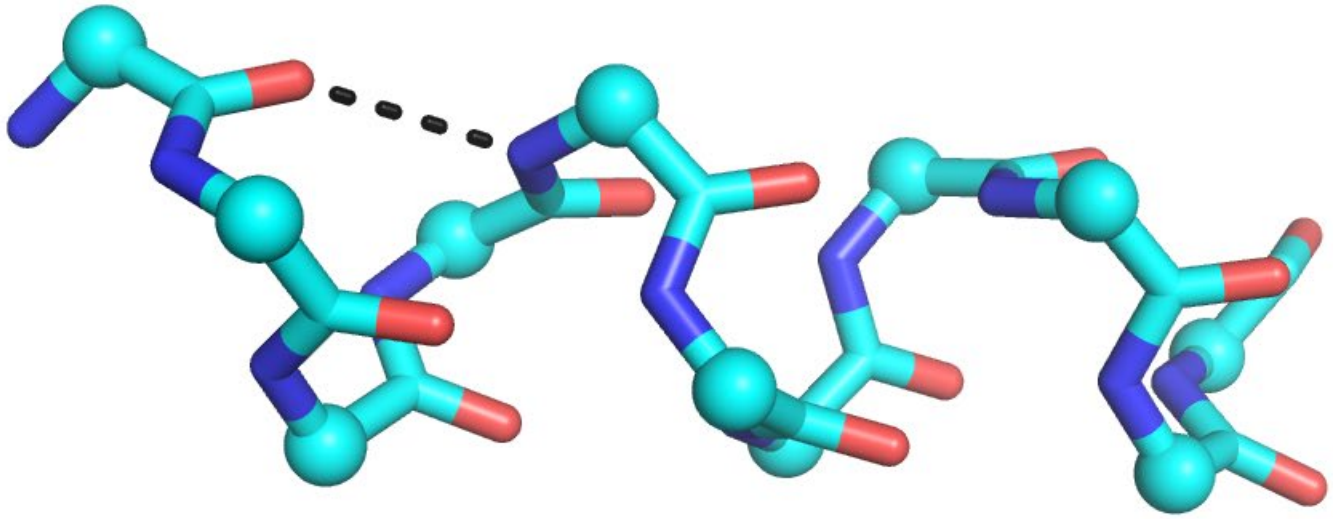


Recall the planar trans-peptide group（反式肽平面）

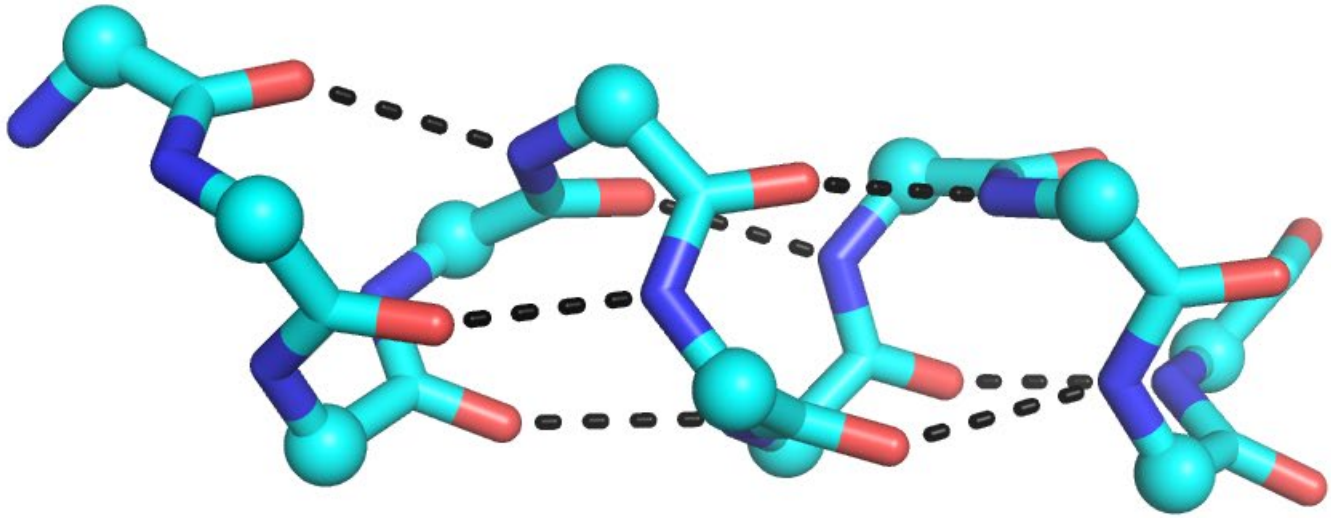


Cα highlighted!

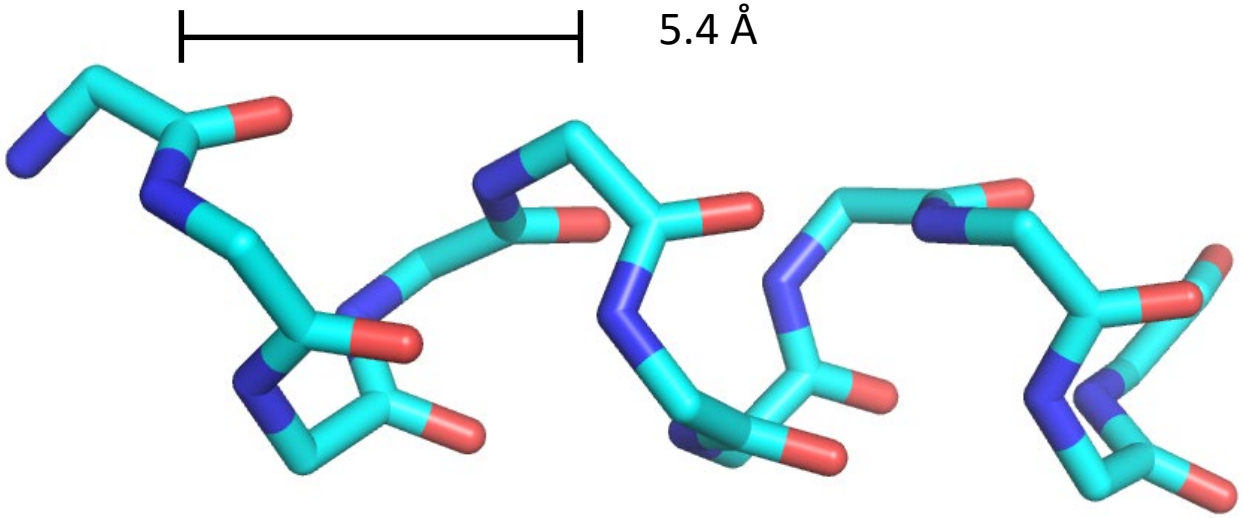
α helix



α helix

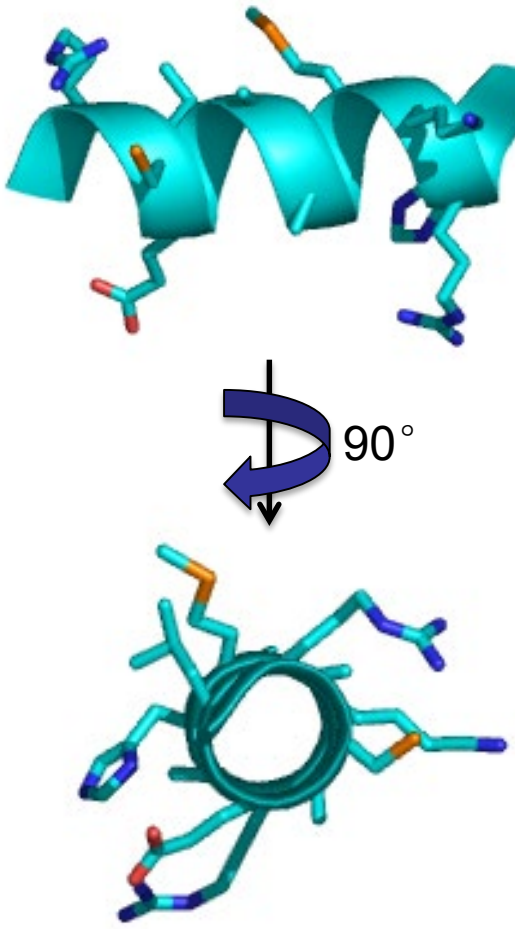


The α helix



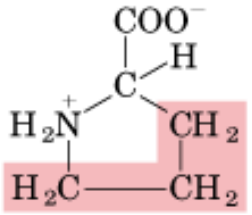
- To make optimal use of internal hydrogen bonds.
- Only right-handed helix.
- Every helical turn extends about 5.4 Å along the axis.
- Every helical turn includes 3.6 residues, so that every residue turns 100 degrees.

An α helix in lysozyme: RCELAAAMKRH



Interaction between side chains of residue i and i+3 or i+4;

Pro rarely appears in α helix .



THE STRUCTURE OF PROTEINS: TWO HYDROGEN-BONDED HELICAL CONFIGURATIONS OF THE POLYPEPTIDE CHAIN

By Linus Pauling, Robert B. Corey, and H. R. Branson*

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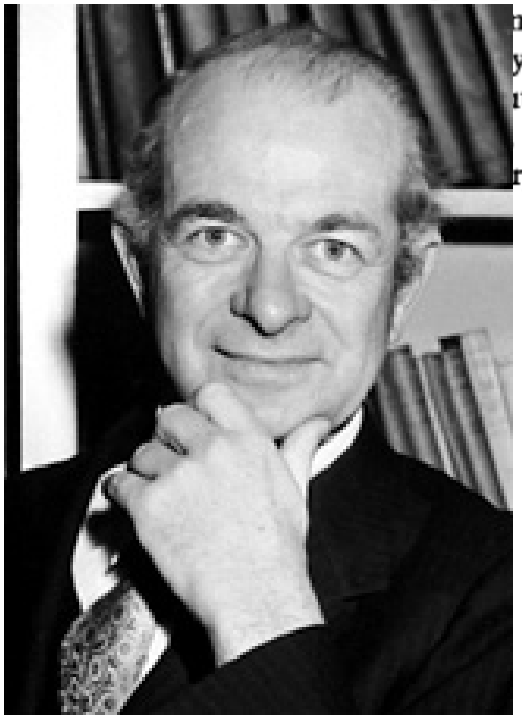
Communicated February 28, 1951

During the past fifteen years we have been attacking the problem of the structure of proteins in several ways. One of these ways is the complete and accurate determination of the crystal structure of amino acids, peptides, and other simple substances related to proteins, in order that information about interatomic distances, bond angles, and other configurational parameters might be obtained that would permit the reliable prediction of reasonable configurations for the polypeptide chain. We have now used
nstruct two reasonable hydrogen-bonded helical con-
ypeptide chain; we think that it is likely that these
ite an important part of the structure of both fibrous
as well as of synthetic polypeptides. A letter an-
ry was published last year.[1]



Linus Pauling (1901-1994) got the Nobel Prize in Chemistry in 1954 “for his research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances”.

Next time:

Protein structure.