BCH370 Physical Methods in Biochemistry

Introduction:

Marv Hackert – WEL 5.266B Tu 1-2; F 10:30-11:30
(Main 101)

Ashley Jewett - WEL 4.238 M 10-11; W 5-6

Course grades will be based on points earned out of 480 total points.

Exam 1, Exam 2, Exam 3:	**100 pts each**	**= 300 pts**
Blast Assignment:	**60 pts**	**= 60 pts**
Graded Homework 1, 2, 3:	**20 pts each**	**= 60 pts (due 8:00 am)**
Term Paper / Special Assignment:	**60 pts each**	**= 60 pts**

http://hackert.cm.utexas.edu/courses/bch370/fall2014/

International Union of Crystallography - EC

Back row: M Cooper, M Dacombe, M Guss, R Kuzel, M Takata, W Depmeier, S Gracia-Granda
Front row: H Dabkowska, L Van Meervelt, M Hackert, M Glazer, G Desiraju

IUCr – promotes all aspects of crystallography, international publication of crystallographic research (***Acta Cryst. A*** → ***F***), facilitates standardization of methods, units, nomenclatures and symbols, sponsors education and training, international meetings.

2014 international year of crystallography IUCr


PRE VET
PTO
BETA


TEXAS


BHPO
Forever




Review of Amino Acids & Peptide:

Goals for this review unit:

1. **Review meaning of pKa / titration behavior**
2. **Recognize the common building blocks of amino acids**
   - recognize structures
3. **Nomenclature - names / 3-letter & 1-letter abbrev.**
4. **Ionic properties of a.a. - pKa (know pKa's of 20 common a.a.)**
5. **Peptides and the Peptide bond**
6. **Ionic properties of peptides and proteins**

K_a and pK_a describe how completely a weak acid dissociates.

$$HA \rightleftharpoons H^+ + A^-$$

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

$$pK_a = -\log_{10} K_a$$

The pK_a of a weak acid is the pH at which [HA] = [A^-]

Example: acetic acid has a pKa of 4.7

$$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$$

So, in a solution of acetic acid at pH 4.7,

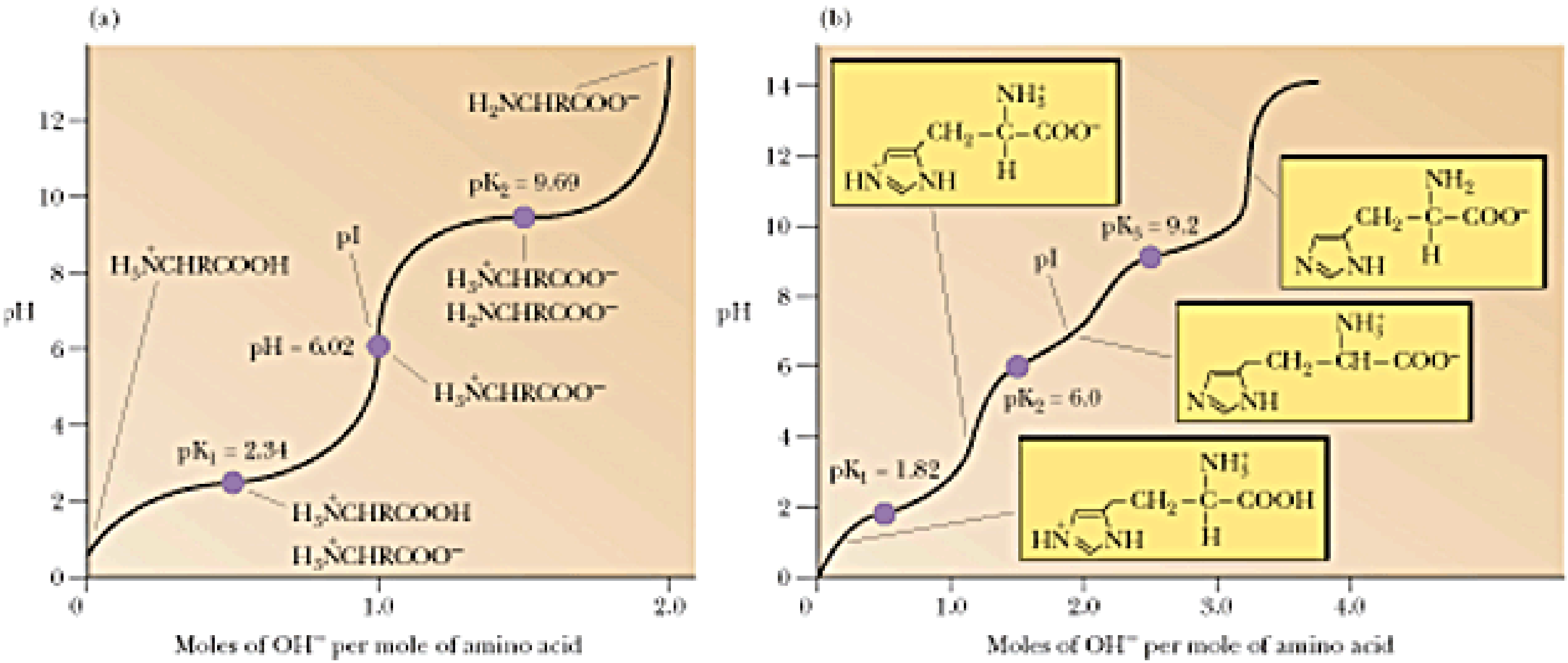
CH_3COOH and CH_3COO^- are present in equal amounts.

The Henderson-Hasselbalch equation describes how much of a weak acid is ionized at a particular pH:

$$pH = pKa + \log \frac{[\text{conjugate base}]}{[\text{acid}]}$$

The Henderson-Hasselbalch equation says: A change of one pH unit changes the ratio of acid to conjugate base by a factor of ten.

pH	Ratio [CH_3COOH] / [CH_3COO^-]
3.7	[10] / [1]
4.7	[1] / [1]
5.7	[1] / [10]



ⅭBC 3E Fig. 03.07 #307
Artist: JKM 02/17/98 C M Y K

Some pK_a values that every biochemist should know:

carboxyl group:	pKa typically about 2	2
amine:	pKa typically about 10	10

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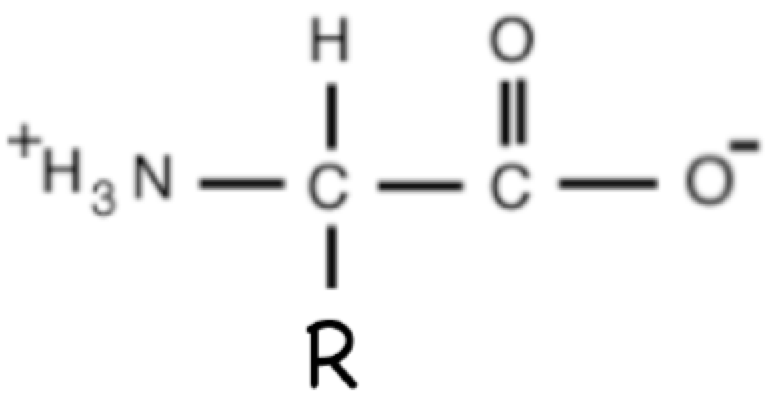
pK_a values for some amino acid side chains:

Asp & Glu	pK_a is about 4	4
Lysine	pK_a is about 10.5	10
Arginine	pK_a is about 12	12
Tyrosine -OH	pK_a is about 10	10
Cysteine -SH	pK_a is about 8.3	8
Histidine ring	pK_a is about 6	6

First regular course topic:

"Our friends the amino acids".

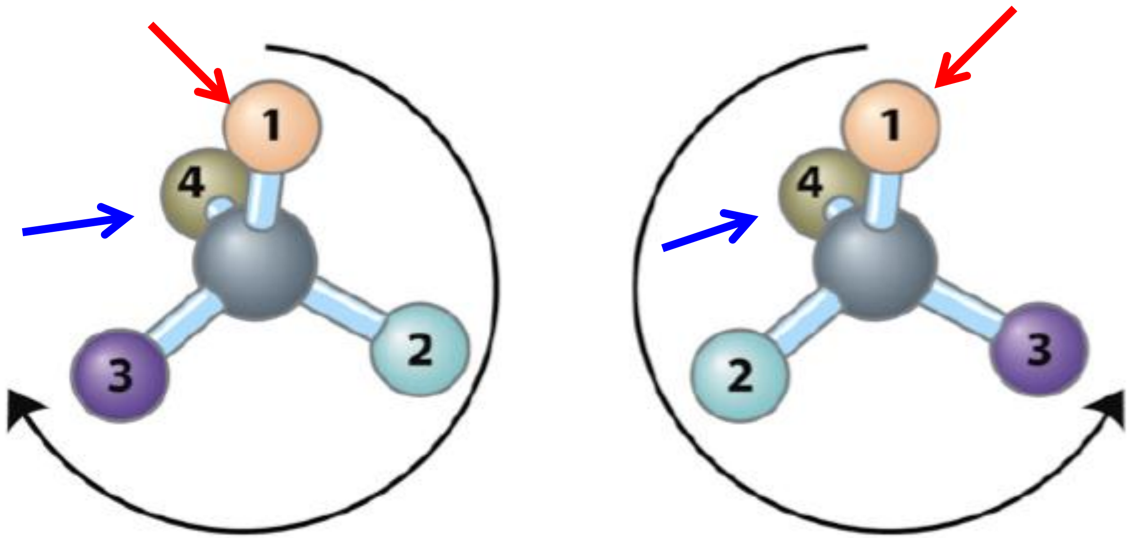
One letter abbreviation, 3 letter abbreviation, properties, structure.



"R" group is different, depending on a.a. type.

Amino acids are chiral.

RS system of classifying enantiomers (Cahn-Ingold Prelog, or CIP system, established in 1960's).



Clockwise
(*R*)

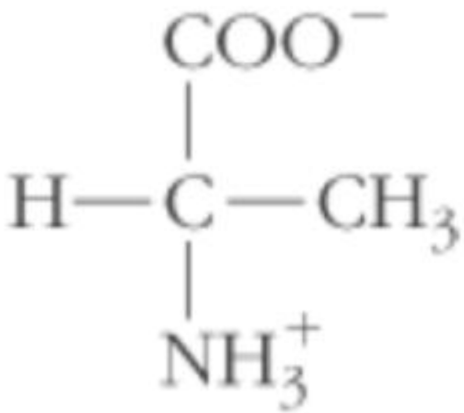
Counterclockwise
(*S*)

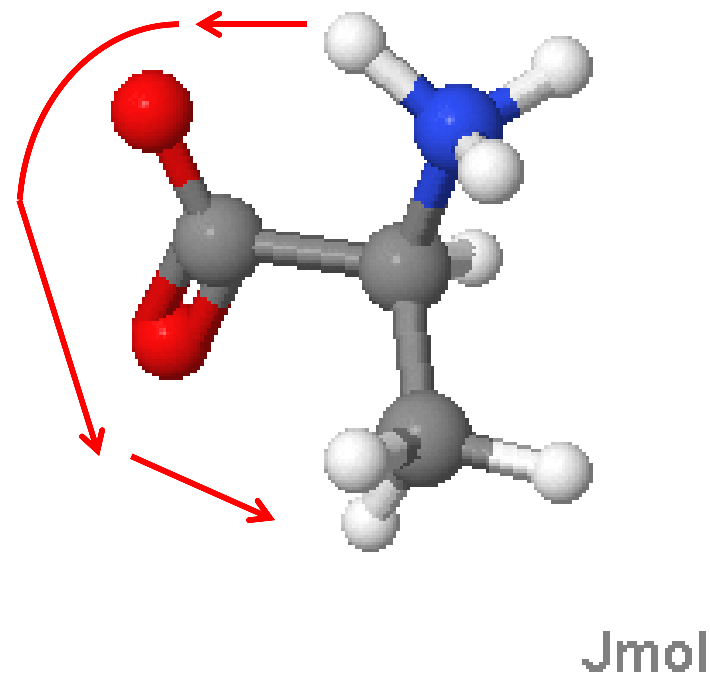
1 = highest priority group (based on atomic # of attached substituents)

With lowest priority group pointing away from observer, decreasing priority of other 3 substituents goes in clockwise direction for R enantiomer.

http://www.chem.ucalgary.ca/courses/351/Carey5th/Ch07/ch7-6.html

Example: Alanine found in proteins is the S enantiomer.





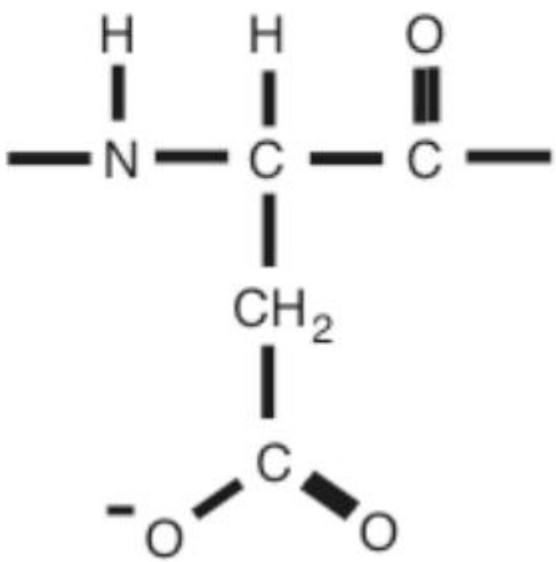
alanine

Note: Amino acid enantiomers are often classified by the "DL" system, from the 1890's. The amino acids normally found in proteins are "L-amino acids". For example, "L-alanine".

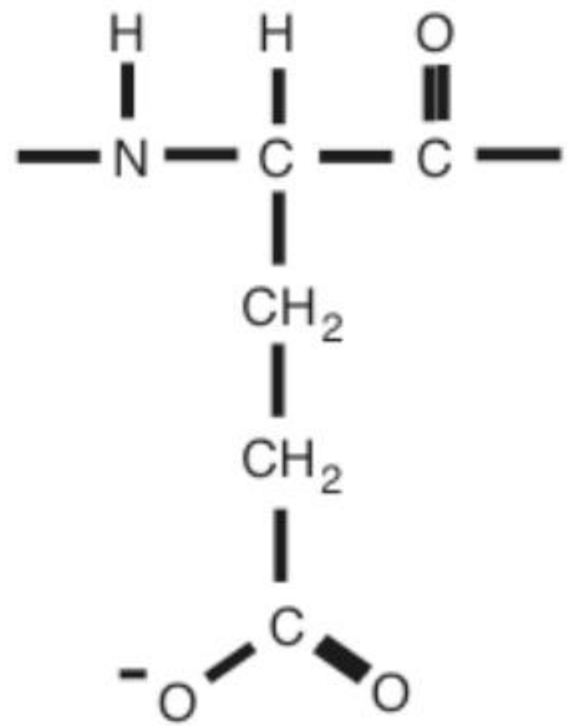
A few words about each of the 20 common amino acids.

Charged amino acids - Negative

Aspartic acid (Asp, D)



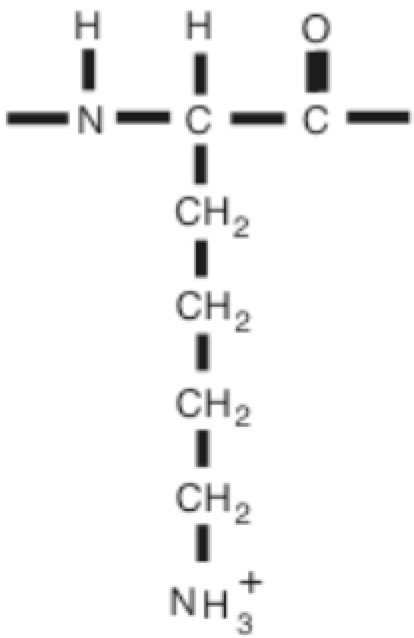
Glutamic acid (Glu, E)



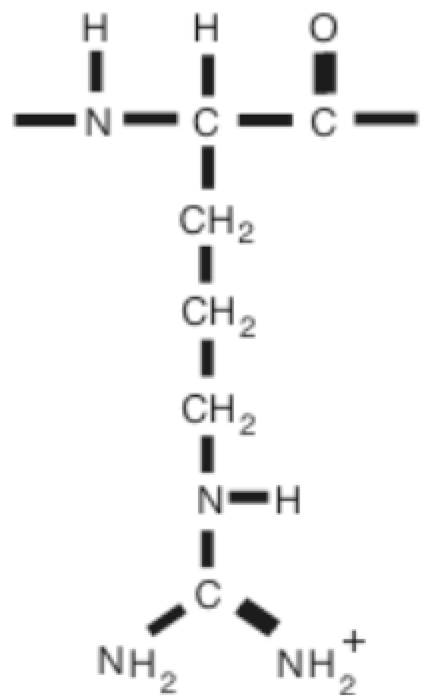
Asp & Glu pK_a is about 4

Charged amino acids - Positive

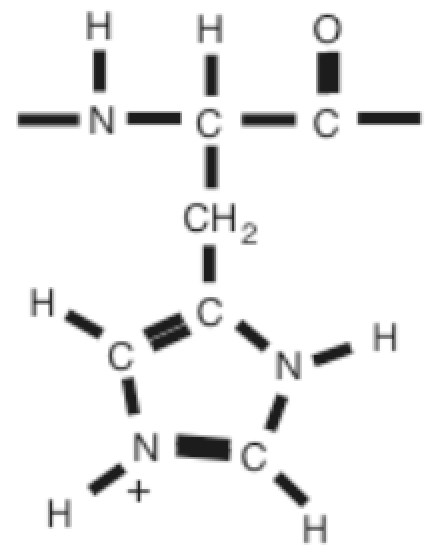
Lysine (Lys, K)



Arginine (Arg, R)



Histidine (His, H)

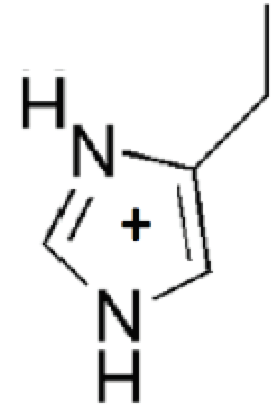


Histidine ring pK$_a$ is about 6

Lysine pK$_a$ is about 10.5

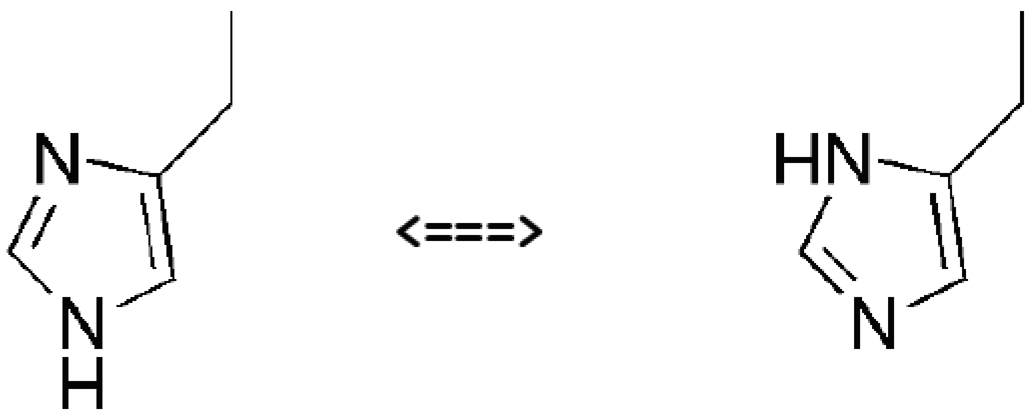
Arginine pK$_a$ is about 12

Histidine side chain
at pH < 6.

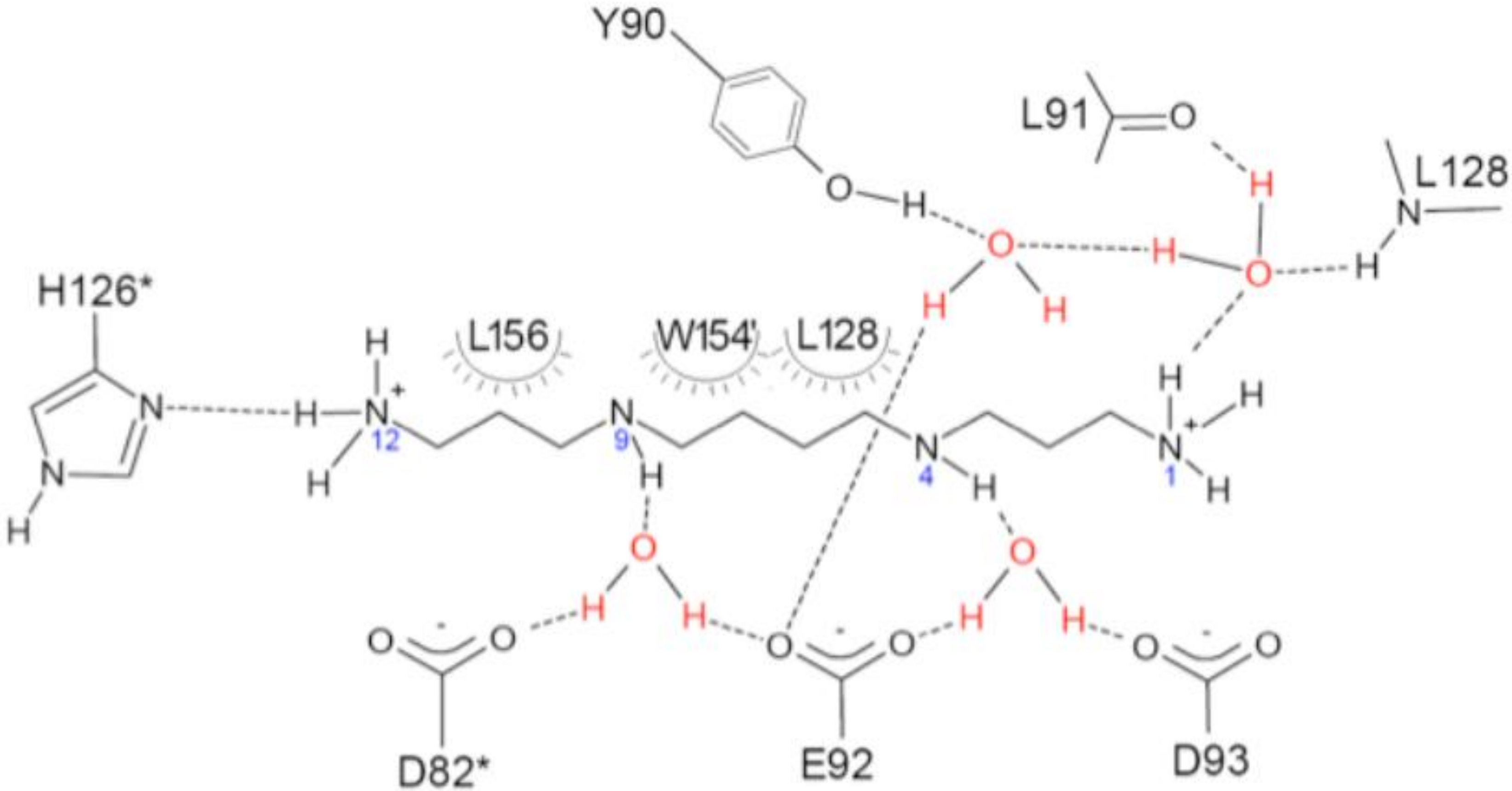


Histidine ring pK_a is about 6

Histidine side chain at pH > 7.



Tautomer of histidine can be identified from hydrogen bonding network in well-ordered crystal structures.

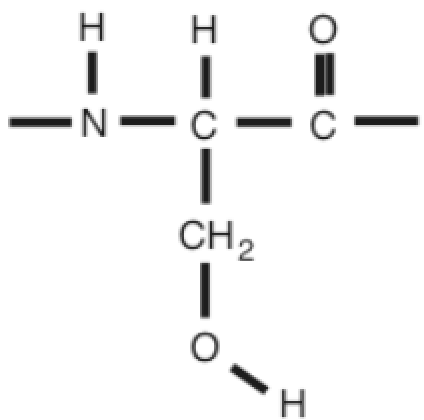


Both histidine tautomers have been observed in crystal structures.

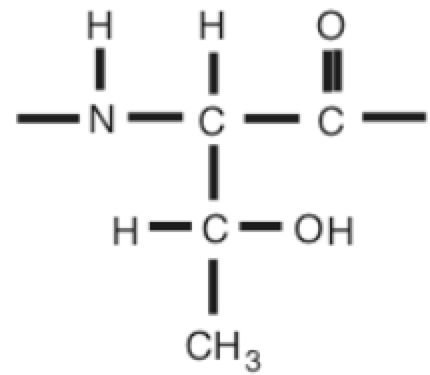
Amino acids - Hydrophilic

Serine, threonine, glutamine, asparagine - can form H-bonds with water.

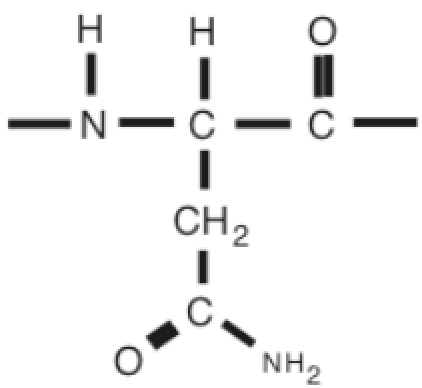
serine (Ser, S)



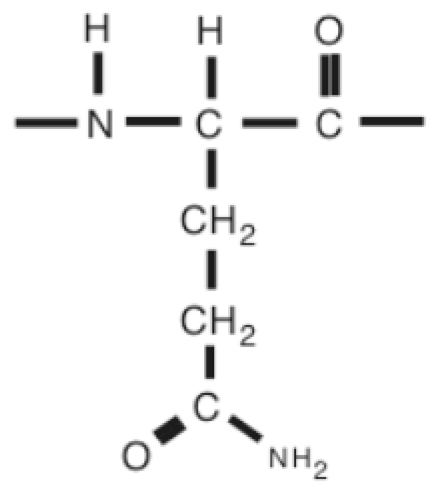
threonine (Thr, T)



asparagine (Asn, N)

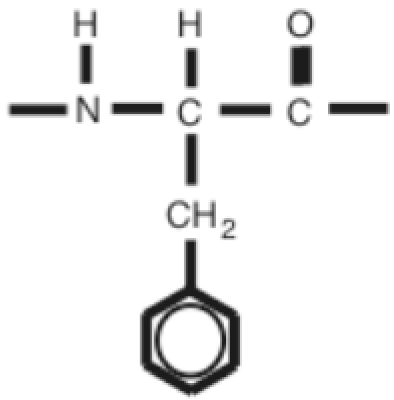


glutamine (Gln, Q)

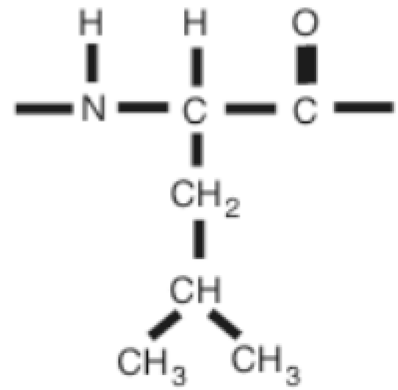


Amino acids - Very hydrophobic

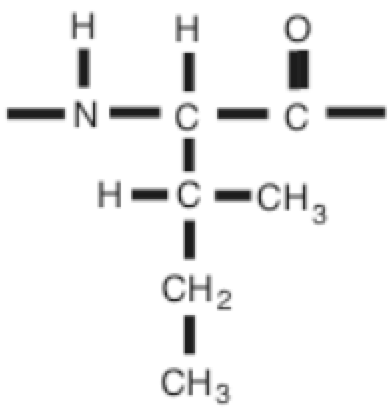
phenylalanine (Phe, F)



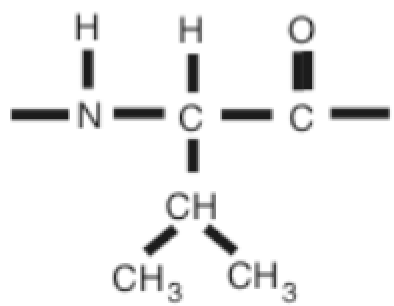
Leucine (Leu, L)



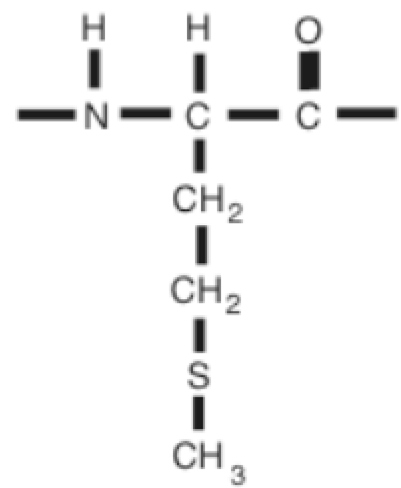
Isoleucine (Ile, I)



Valine (Val, V)

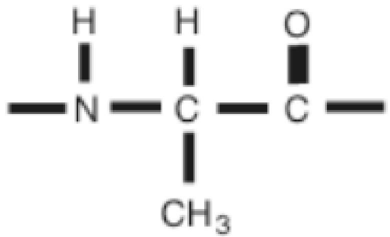


Methionine (Met, M)

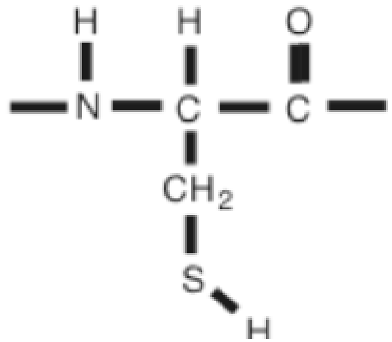


Other (moderately) hydrophobic amino acids

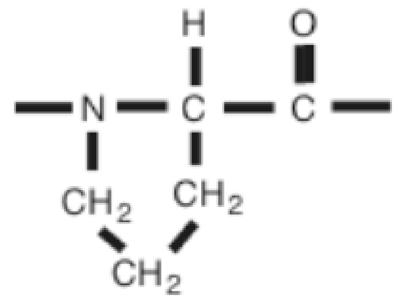
Alanine (Ala, A)



Cysteine (Cys, C)

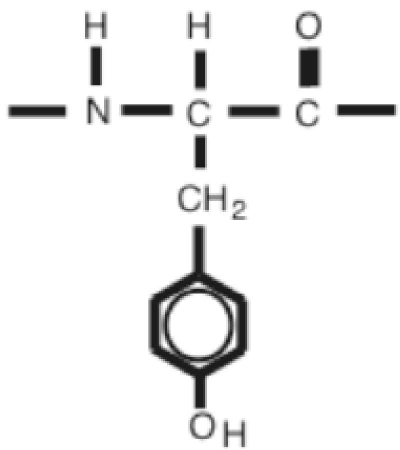


Proline (Pro, P)

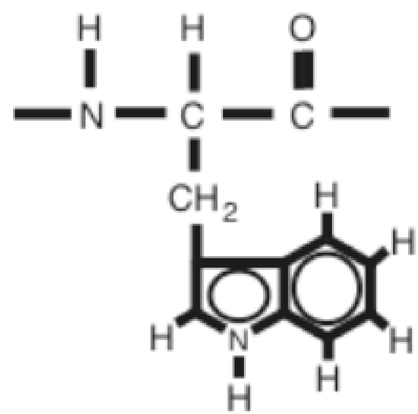


Cysteine -SH pK$_a$ is about 8.3

Tyrosine (Tyr, Y)



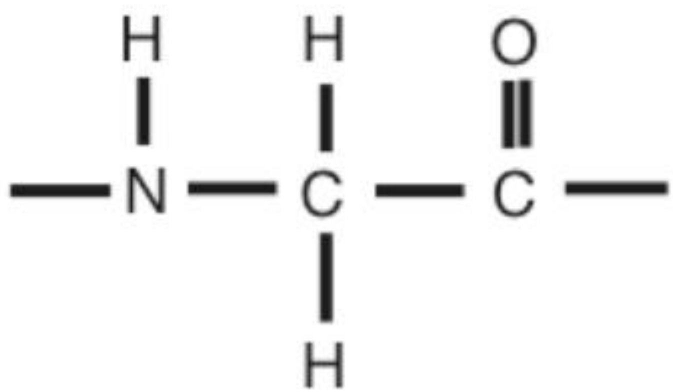
Tryptophan (Trp, W)



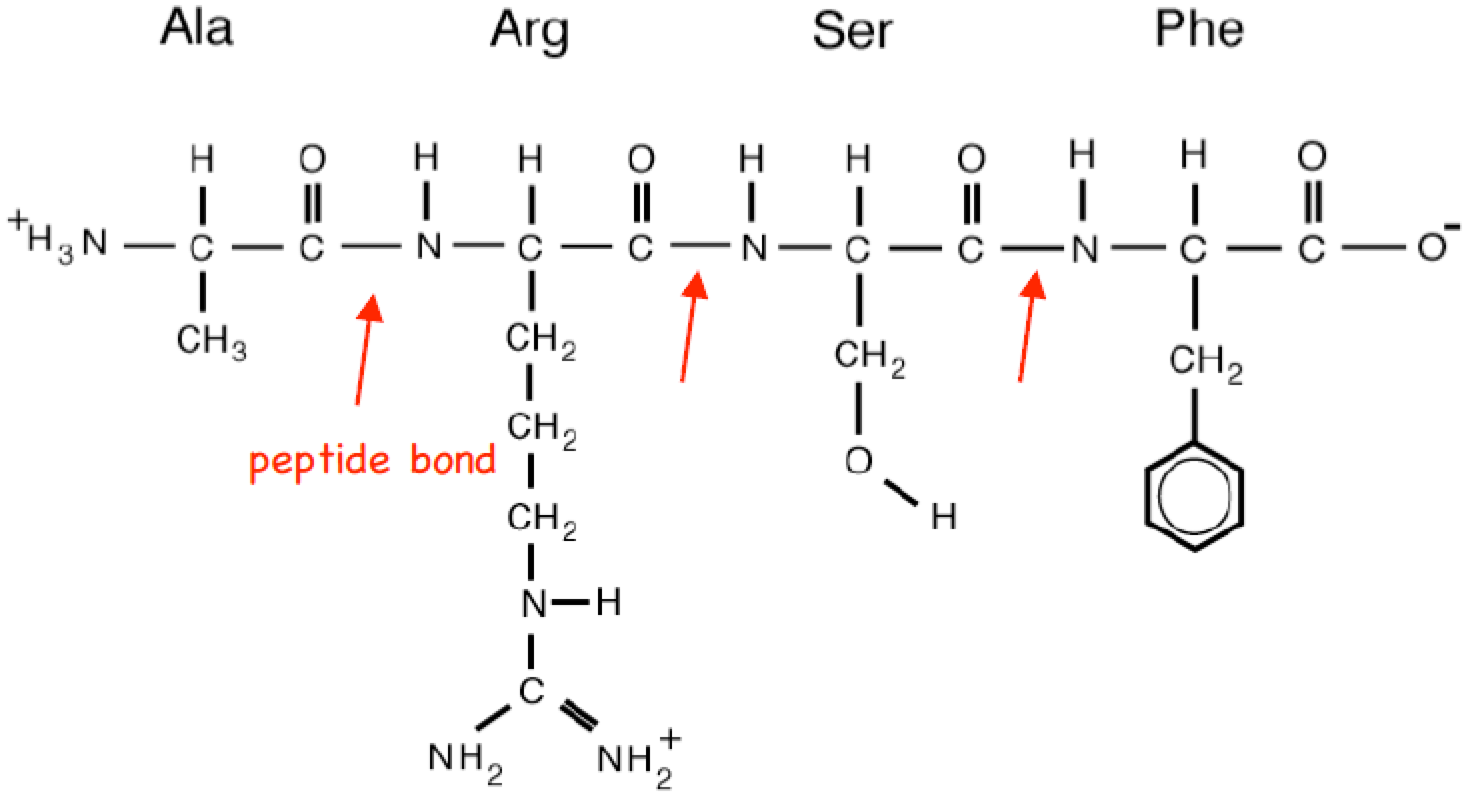
Tyrosine -OH pK$_a$ is about 10

.... and glycine

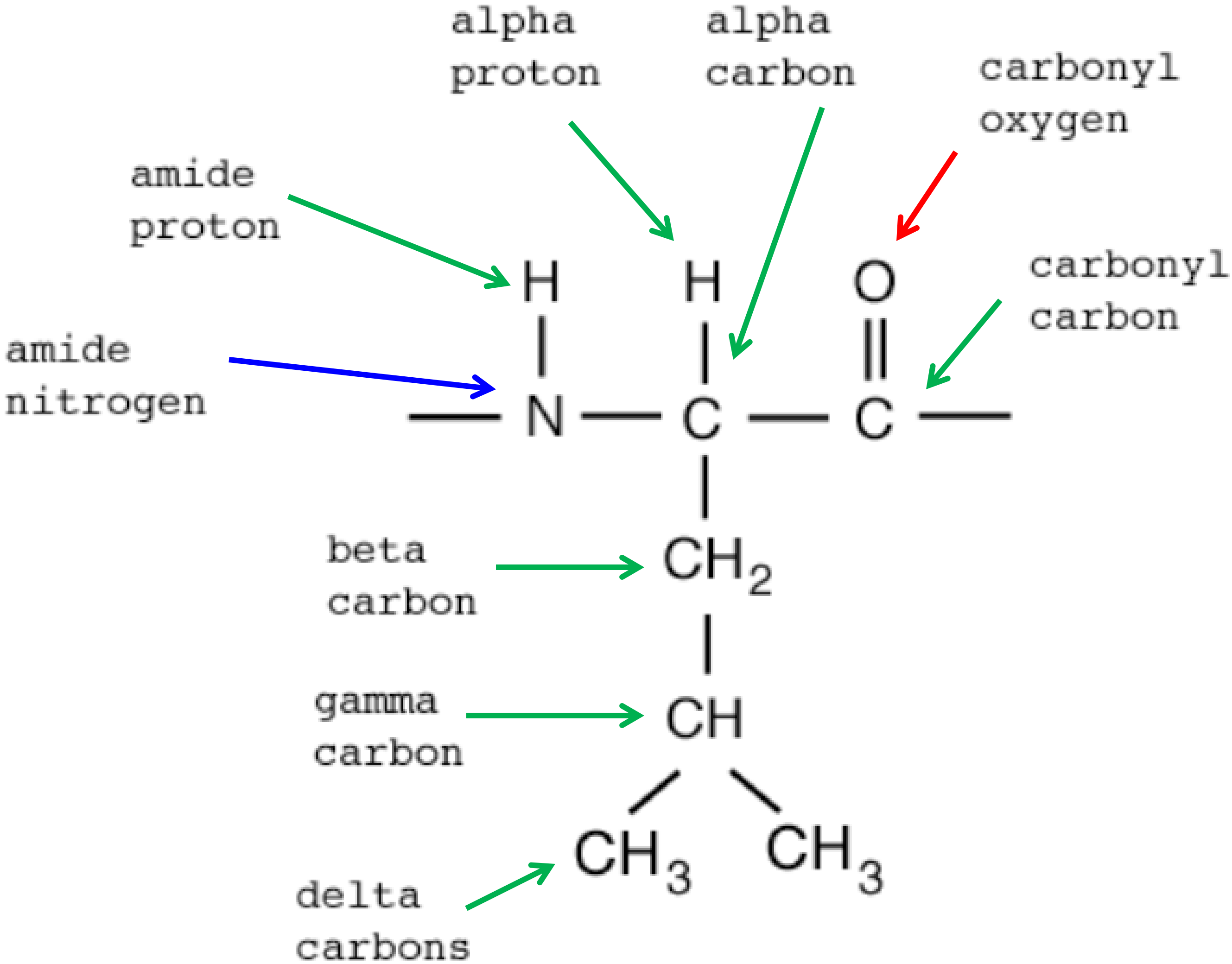
Glycine (Gly, G)



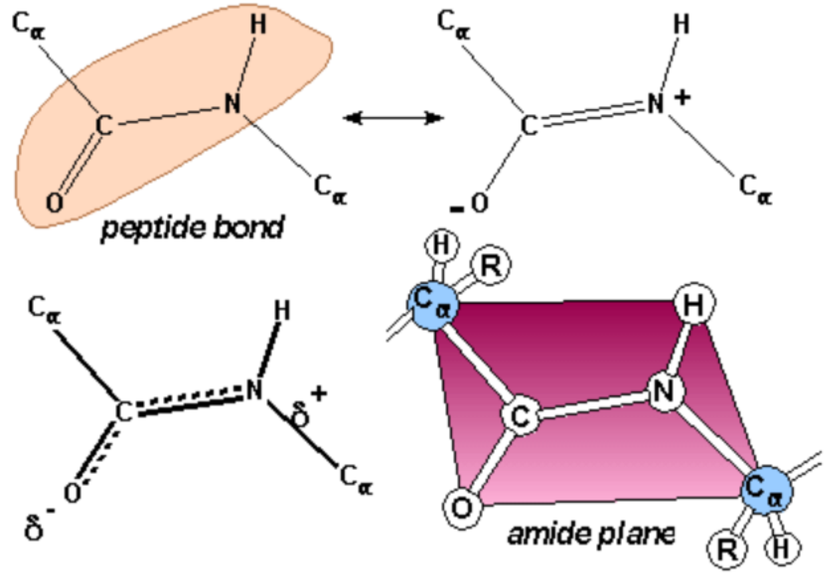
Linkage of amino acids in a protein.



Nomenclature

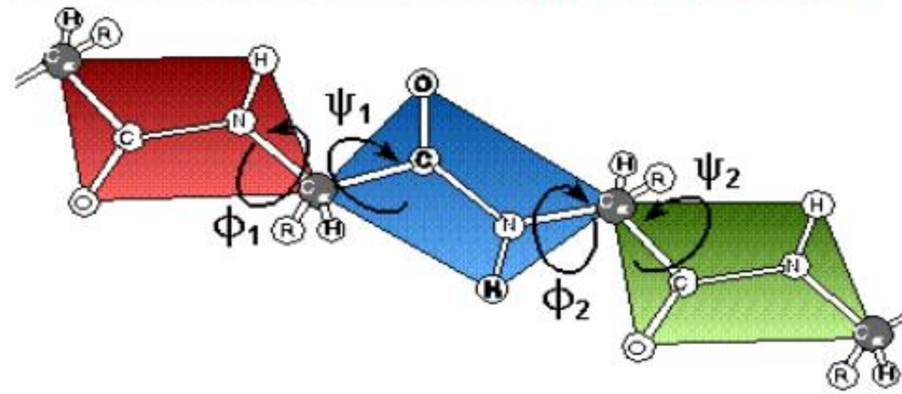


Chemistry of the peptide bond



This image was created by Dr. George Helmkamp, Jr. (UKMC)

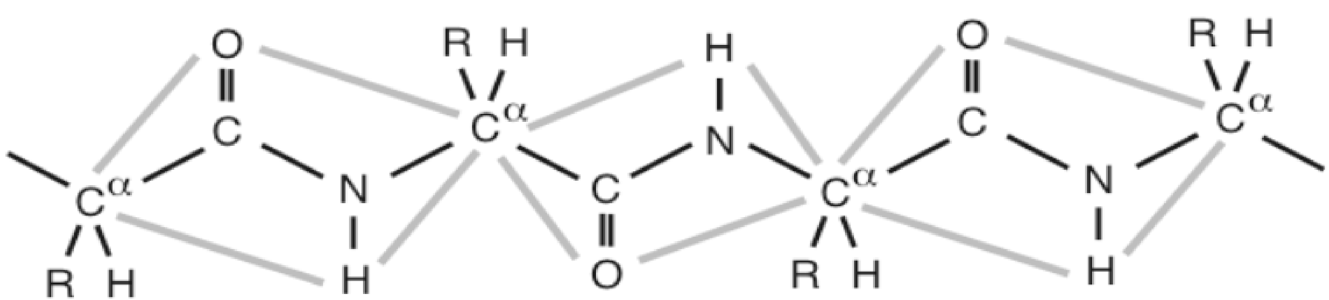
Conformation of a polypeptide



ϕ - rotation around the N-C_α bond

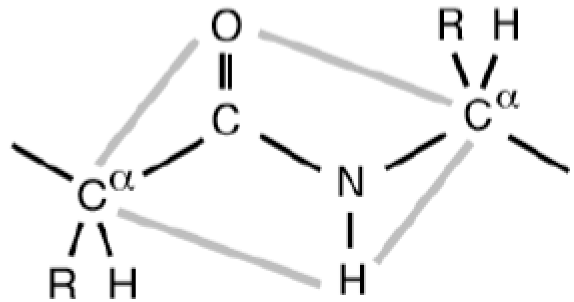
ψ - rotation around the C_α-C bond

Planar units within peptides are relatively rigid due to partial double bond character of C - N bond.

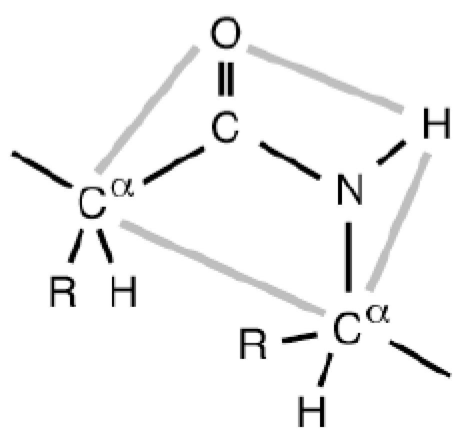


Peptide bonds can be cis or trans,
but within proteins are almost always trans.

trans



cis



Describe the charges on a tripeptide with sequence:

Ala-Lys-Cys at pH = 7

At what pH would this tripeptide have a charge of zero?

(this is the "isoelectric point" of the peptide)

http://web.expasy.org/compute_pi/

Some pK_a values that every biochemist should know:

carboxyl group:	pKa typically about 2	2
amine:	pKa typically about 10	10

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pK_a values for some amino acid side chains:

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Histidine ring	pK_a is about 6	6

Primary, secondary, tertiary structure of proteins.

Primary structure is just the a.a. sequence.

Secondary structure describes which parts of the protein are helices, beta strands, turns.

←— β-strand —→ ←— α-helix —→ ←— β-strand —→

1 5 10 15 20 25

G K S D K I I P I A E N K E A K A K Y D I L E T Y E A G I

Tertiary structure describes 3-D fold.