Amino Acids

(9/08/2009)

1. What are Amino Acids, and what is their 3-D structure?

2. What are the structures & properties of the individual amino acids?

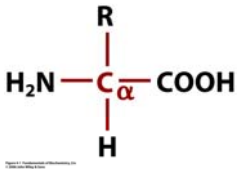
3. What is the peptide bond?

4. Do amino acids have specific Acid-Base properties?

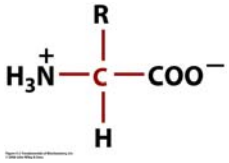
5. Are small peptides physiologically active?

Amino Acids

The building blocks of proteins



α-amino acids because of an amino group next to the Cα
R group - determines the identity of the particular amino acid
Stereochemistry - important property



Amino acids are Ampholytes

$pK_1 \approx 2.2$ while $pK_2 \approx 9.4$, pK_R for R group pK's
In the physiological pH range, both NH_2 and COOH are completely ionized
They can act as either an acid or a base

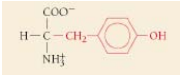
They are Zwitterions, molecules having charged groups of opposite polarity

Because of their ionic nature they have extremely high melting temperatures

Amino Acids

You must know:

Their names
Their structure
Their three letter code
Their one letter code



Tyrosine, Tyr, Y, aromatic, hydroxyl

Classification and Characteristics of Amino Acids

R polarity: three main categories to describe amino acids:

1) Non polar "hydrophobic" nine in all
Glycine, Alanine, Valine, Leucine, Isoleucine, Methionine, Proline, Phenylalanine and Tryptophan

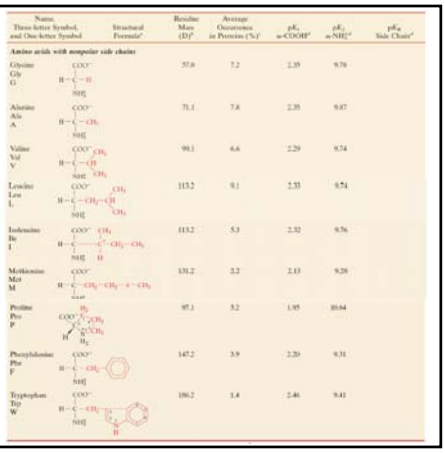
2) Uncharged polar, six in all
Serine, Threonine, Asparagine, Glutamine, Tyrosine, Cysteine

3) Charged polar, five in all
Lysine, Arginine, Glutamic acid, Aspartic acid, and Histidine

Key to structure

(1)

G
A
V
L
I
M
P
F
W



(2)

S

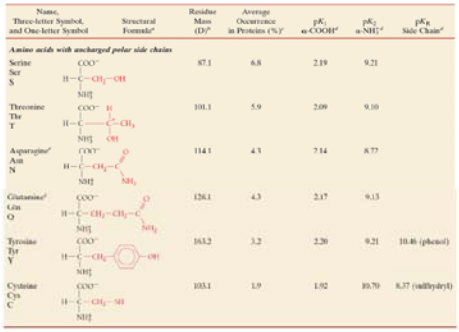
T

N

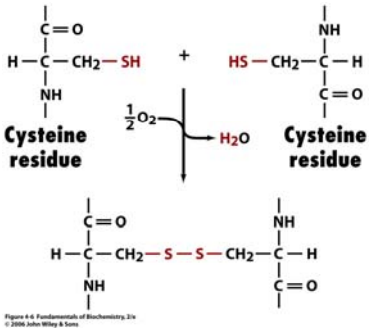
Q

Y

C



Cystine consists of two disulfide-linked cysteine residues



(3)

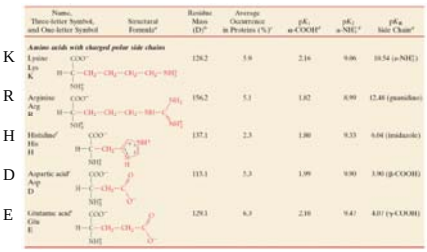
K

R

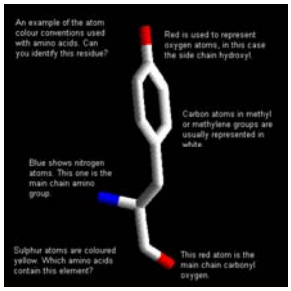
H

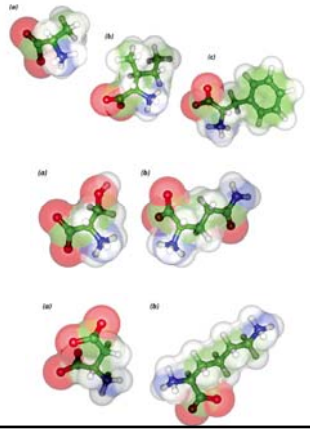
D

E



Color conventions



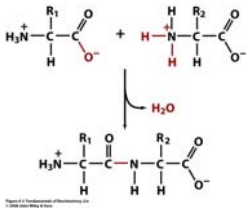


(1)

(2)

(3)

Amino acids can form peptide bonds CO-NH linkage



- Amino acid residue
- Dipeptides, tripeptides, oligopeptides
- Polypeptides
- Proteins consist of one or more PP

Peptides are linear polymers that range from 8 to 4000 amino acid residues

Twenty (20) different naturally occurring amino acids

Linear arrays of amino acids can make a huge number of molecules

Consider a peptide with two amino acids

AA1 – AA2

20 x 20 = 400 different molecules

AA1 – AA2 – AA3

20 x 20 x 20 = 8000 different molecules

For 100 amino acid protein the # of possibilities are:

$$20^{100} = 1.27x10^{130}$$

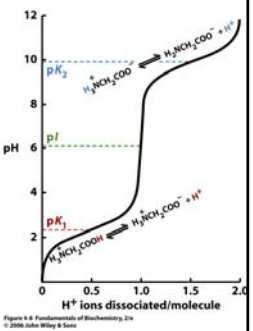
The total number of atoms in the universe is estimated at $9x10^{78}$

Acid - Base properties of amino acids

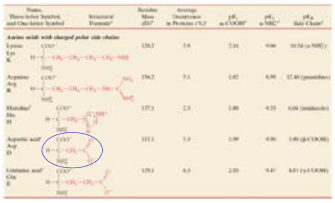
$$pH = pK + \log\left(\frac{[A^-]}{[HA]}\right)$$

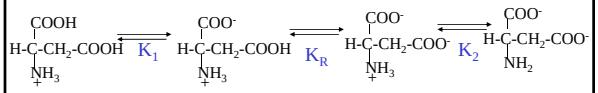
Isoelectric point: the pH where a protein carries no net electrical charge

$$pI = \frac{1}{2}(pK_i + pK_j)$$



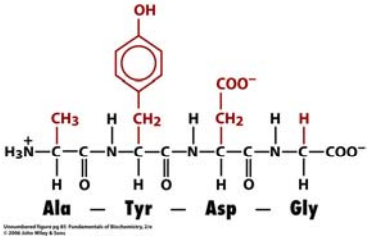
For a monoamino-monocarboxylic residue
pKi = pK_1 and pKj = pK_2 ;
For D and E, pKi = pK_1 and pKj - pK_R ;
For R, H and K, pKi = K_R and pKj = pK_2





+1 0 -1 -2

Nomenclature

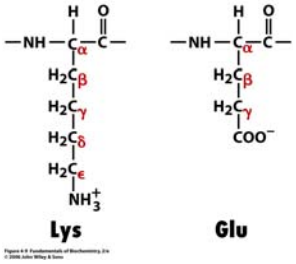


The tetrapeptide Ala-Tyr-Asp-Gly or AYDG

Greek alphabet

Beginner's guide to the Greek alphabet.

α	alpha
β	beta
γ	gamma
δ	delta
ε	epsilon
ζ	zeta
η	eta
θ	theta
ϕ	phi
χ	chi
ψ	psi
ω	omega



Greek lettering used to identify atoms in lysine or glutamate

Stereochemistry

Optical activity - The ability to rotate plane - polarized light

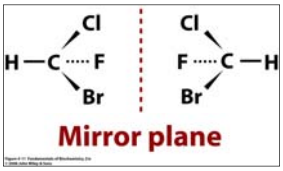
Asymmetric carbon atom

Chirality - Not superimposable

Mirror image - enantiomers

(+) Dextrorotatory - right - clockwise

(-) Levorotatory - left counterclockwise



Operational definition only

Cannot predict absolute configurations

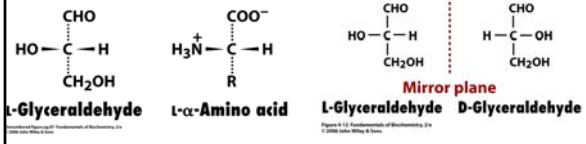
The Fischer Convention

Absolute configuration about an asymmetric carbon

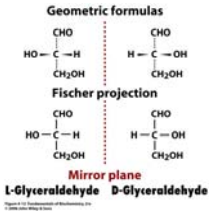
related to glyceraldehyde

(+) = D-Glyceraldehyde

(-) = L-Glyceraldehyde

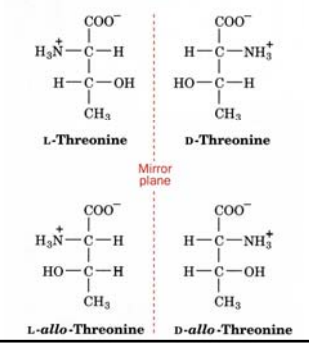


All naturally occurring amino acids that make up proteins are in the L conformation



In the Fischer projection all bonds in the horizontal direction is coming out of the plane of the paper, while the vertical bonds project behind the plane of the paper

An example of an amino acid with two asymmetric carbons



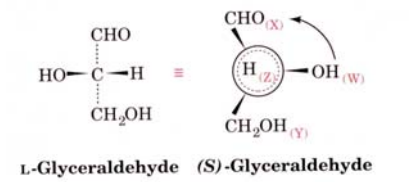
Cahn - Ingold - Prelog system

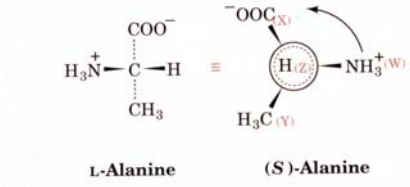
Can give absolute configuration nomenclature to multiple chiral centers.

Priority

Atoms of higher atomic number bonded to a chiral center are ranked above those of lower atomic number with lowest priority away from you R highest to lowest = clockwise, S highest to lowest = counterclockwise

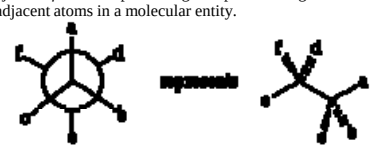
SH>OH>NH_2>COOH>CHO>CH_2OH>C_6H_5>CH_3>H





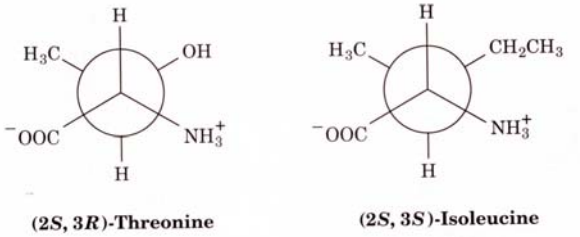
Newman Projection

- *A projection formula* representing the spatial arrangement of bonds on two adjacent atoms in a molecular entity.



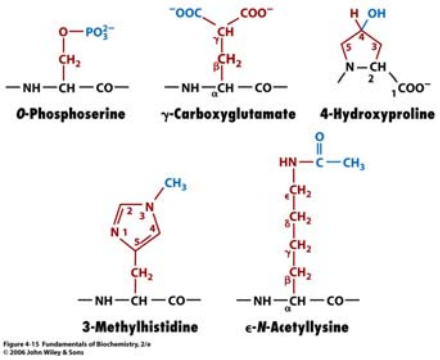
- The structure appears as viewed along the bond between these two atoms, and the bonds from them to other groups are drawn as projections in the plane of the paper.
- The bonds from the atom nearer to the observer are drawn so as to meet at the centre of a circle representing that atom.
- Those from the further atom are drawn as if projecting from behind the circle.

The major advantage of the CIP or RS system is that the chiralities of compounds with multiple asymmetric centers can be unambiguously described

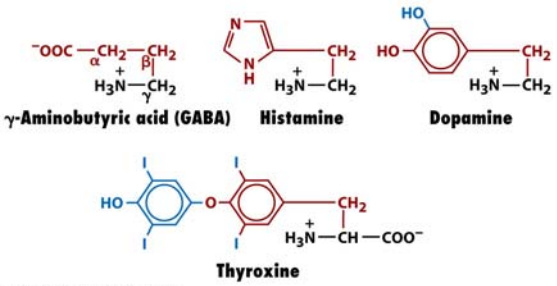


(2*S*, 3*R*)-Threonine (2*S*, 3*S*)-Isoleucine

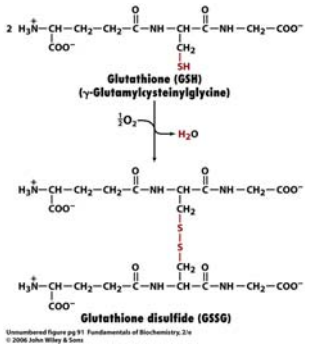
Side Chain Modifications in Proteins



Biologically Active Amino Acids



Oxidation and Reduction of Glutathione



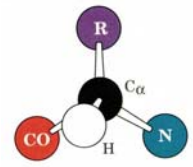
Questions:

1. For the dipeptide Tyr-Asp, find ***pI*** (the pKs are α-amino 9.2, phenolic 10.5, β-carboxylate 3.9, α-carboxylate 2.0).

2. For the dipeptide Lys-Glu, find ***pI*** (the pKs are α-amino 9.1, ε-amino 10.5, γ-carboxylate 4.1, α-carboxylate 2.1).

Lecture 6
Thursday 9/10/09
Amino Acids

The CORN method for L isomers: put the hydrogen towards you and read off CO R N clockwise around the Cα This works for all amino acids.



CORN LAW amino acid with L configuration