MMBB 300/380 - Lecture 3
Amino Acids (Lehninger 4th Ed: pg 75-85)

Proteins are biological macromolecules; linear arrays of:

Amino acids: molecules that contain at least one each of the following:

1) 2)

Examples:

glycine
(α-amino acid) (β-amino acid) (γ-amino acid)

α, β, γ, δ, etc, refer to the position of:

Many different amino acids can be imagined theoretically or synthesized in the lab. Only _____ are used to synthesize proteins in a typical cell.
These common amino acids are all:

I. Twenty amino acids may not seem like very many building blocks, especially considering the genomes of some of the higher eukaryotes may encode:

Consider this: Each polypeptide or protein consists of a linear array of amino acids. How many different 10 amino acid polypeptides can be synthesized from the 20 common amino acids?

Two examples of decapeptides (10 amino acids).

ala-ala-ala-ala-ala-ala-ala-ala-ala-ala (One boring possibility)

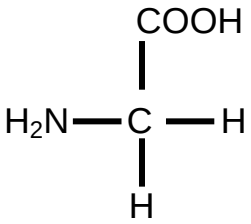
ala-gly-phe-pro-glu-cys-thr-ser-val-met (Decapeptide with 10 different aa)

OK, that's two. How many more are there?

The first amino acid can one of twenty choices. The second and each subsequent amino acid can also be one of twenty choices. Therefore, the total number of possible decapeptides is:

Using a 20 aa alphabet, there are over different decapeptides!!!

II. Amino acids are ionized in aqueous solutions at neutral pH.



(glycine as solid) (glycine in H_2O, pH 7) (glycine in H_2O, pH 1) (glycine in H_2O, pH 12)

The *overall charge* of glycine in a neutral solution (pH 7) is: _____. The amino and carboxylate groups, however, both carry a charge. This is an example of a:

All 20 common amino acids behave similarly; ie, the amino group is_____ at neutral and acidic pH, while the carboxylate group is _____ at neutral and basic pH. More specifically, the pK_a (pK_{a1}) of each alpha carboxylic acid group is: while the pK_a (pK_{a2}) of each alpha amino group

pK_a values for some amino acids

aa	pK_1 (COOH)	pK_2 (NH_3^+)	pK_R
Glycine	2.34	9.60	
Alanine	2.34	9.69	
Leucine	2.36	9.60	
Serine	2.21	9.15	
Threonine	2.63	10.43	
Glutamine	2.17	9.13	
Aspartate	2.09	9.82	3.65
Glutamate	2.19	9.67	4.25
Histidine	1.82	9.17	6.00
Cysteine	1.71	10.78	8.18
Tyrosine	2.20	9.11	10.07
Lysine	2.18	8.95	10.53
Arginine	2.17	9.04	12.48

Therefore, in aqueous solutions:

When: pH < 2

When: 3 < pH < 9

When pH > 10

III. Sterochemistry. The α-carbon atom is chiral.

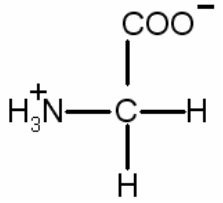
For every chiral carbon (happens whenever 4 *different* groups are bound to a single carbon), there will be two different mirror image isoforms. The two mirror image forms are called the L & D isomers (based on opposite optical rotation of plane-polarized light; L = levorotary & D = dextrorotatory).

Only the_____of amino acids occur in proteins.

Some_____amino acids exist (ie, in peptidoglycan cell walls of bacteria).

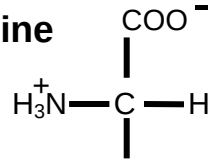
IV. Properties of the 20 amino acids.

The 20 common amino acids differ by a "side group" or "functional group" which is bound to the α-carbon. These side groups confer very different behavior on the various amino acids. The behaviors are grouped below.

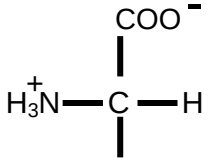
AMINO ACID	STRUCTURE (pH 7)	COMMENTS
A. Extremely Small:		
Glycine		Side group is merely hydrogen. Side group is very small.
B. Aliphatic & Hydrophobic:		Have an aversion to H_2O**;** interact with each other.
Alanine		Small, but considered hydrophobic
Valine		
Leucine		
Isoleucine		

C. Aromatic: The aromatic aa's are mostly hydrophobic.

Phenylalanine

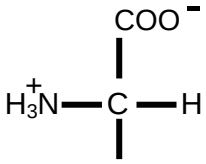


Tyrosine



Simply an alcohol form of Phe. Hydroxyl can be phosphorylated. pK_a of hydroxyl is 10. Partial hydrophillic behaviour.

Tryptophan



Large molar absorptivity @ 280nm Often responsible for majority of a protein's absorbance at 280 nm.

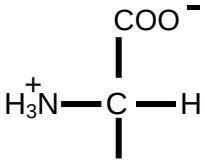
D. Proline

Proline

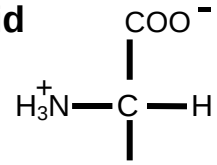
Proline is unique because it is cyclic, nonaromatic, and the side group is bound to the amino group as well as the -carbon. Often breaks up secondary protein structure.

E. Acidic These contain carboxylic acid groups which are negatively charged in most biological conditions.

Aspartic Acid (Aspartate)

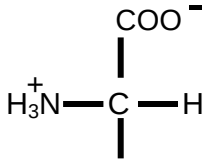


Glutamic Acid (Glutamate)

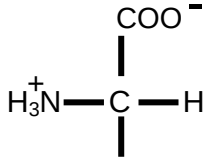


F. Amides These are simply the amide derivatives of the 2 acidic amino acids. They are polar but not charged.

Asparagine

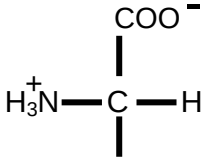


Glutamine



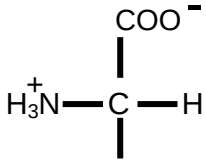
G. Basic The side group of these 3 are usually positively charged in the cell.

Lysine



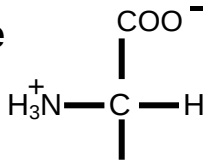
pK_a of ε-amino group is ~10. Usually charged.

Arginine



pK_a of guanido group is ~12. Charged under most conditions.

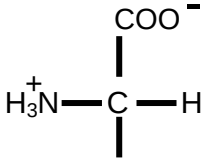
Histidine



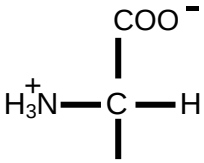
pK_a of imidazole group is ~6.0. pK_a near neutrality allows this aa to participate in many enzymatic reactions and chelation of metal ions

H. Alcohols These contain hydroxyl groups which are polar but rarely charged.

Serine

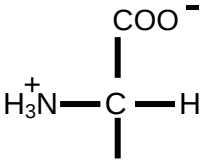


Threonine



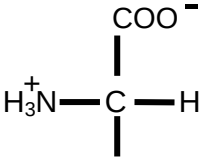
I. Sulfur-containing

Cysteine



Contains “free” sulfur capable of binding a 2nd sulfur to create disulfide bridges.

Methionine



Does not contain a “free” sulfur.