4.3.2

Amino Acid Structure

As stated previously, organization and classification of amino acids is a helpful way to understand and keep track of the different amino acids. Important factors to consider for classification include charge, hydrophilicity or hydrophobicity, size and functional groups (i.e. side chains or R groups). Once the amino acids are incorporated into proteins these factors will influence protein structure, protein-protein interaction, and functionality. The most popular way of organization is to do a structural classification based on the side chains (R-groups). **Note: each identified amino acid (bold) will be followed with the three and one letter symbols)*

Nonpolar, Nonaromatic side chains

Of the twenty amino acids, seven of them fall into this class: Glycine, alanine, valine, leucine, isoleucine, methionine, and proline. **Glycine** (Gly, G), the achiral amino acid already discussed, has a single hydrogen atom as a side chain making it the smallest amino acid and very flexible in its functions. **Alanine** (Ala, A), **Valine** (Val, V), **Leucine** (Leu, L), and **Isoleucine** (Ile, L) have alkyl side chains (*contains only carbon and hydrogen atoms, which are arranged in a chain*) containing one to four carbons. **Methionine** (Met, M) is one of only two amino acids that contains sulfur in the side chain. **Proline** (Pro, P) is a unique amino acid in that it is cyclic. The other 19 amino acids have the amino group attached only to the center carbon (α-carbon), but in proline, the nitrogen from the amino group becomes incorporated in the side chain and results in a conformation resembling a five membered ring. This arrangement makes proline particularly "picky" on how it can be incorporated into other structures (proteins).

Aromatic Side Chains

Three amino acids have aromatic side chains (unsaturated ring of atoms) that are uncharged. Tryptophan, phenylalanine, and tyrosine. **Tryptophan** (Trp, W) has a double ring that contains a nitrogen atom. The side chain of **Phenylalanine** (Phe, F) is a benzyl (benzene rings and an additional CH_2 group) while adding an OH group to phenylalanine makes **Tyrosine** (Tyr, Y). The OH group also make tyrosine polar.

Polar Side Chains (non-aromatic)

Five amino acids have polar side chains: serine, threonine, asparagine, glutamine and cysteine. **Serine** (Ser, S) and **Threonine** (Thr, T) each contain OH groups which influence their polarity and hydrogen bonding capacity. **Asparagine** (Asn, N) and **Glutamine** (Gln, Q) contain amide side chains (RC(=O)NR'R", where R, R', and R" represent organic groups or hydrogen atoms). Amide side chains are stable enough that they do not gain or lose protons during pH changes. The last amino acid in this group is **Cysteine** (Cys, C) which contains a thiol group in it side chain (SH). The large nature of the sulfur group makes it less electronegative (weaker bond) and susceptible to oxidation (loss of electrons). The sulfur group also allows cysteine to form covalent disulfide bonds to other cysteine residues.

Negatively Charged Side Chains (Anionic side chains)

Two amino acids have negative charges on their side chains under physiologic pH (7.4). These amino acids are **Aspartate** (Asp, D) and **Glutamate** (Glu, E). Although often called acids (i.e. aspartic acid and glutamic acid) they actually act as bases, accepting hydrogen in almost all cases.

Positively Charged Side Chains (Cationic side chains)

The remaining amino acids have side chains that contain positively charged nitrogen atoms; lysine, arginine and histidine. **Lysine** (Lys, K) has one amino group while **Arginine** (Arg, R) has three nitrogen atoms. **Histidine** (His, H) contains an aromatic ring with two nitrogen atoms (imidazole).

Amino acids as Acids and Bases

The structure of amino acids makes them some of them function as weak acids or weak bases. These structural components are the carboxy and amino groups as well as some of the functional groups (R-group). Since some amino acids can either accept a proton or donate a proton they can be referred to as **amphoteric** (having dual nature). Additionally, when some amino acids are placed in water at neutral pH, the amino and carboxy groups can become charged (NH_3^+ and CO_2^-) giving them the property of a dipole ion called a **zwitterion**.