Lecture 2

Introduction to Amino acids

We study *amino acids* because they are **the building blocks of proteins**. *Proteins* are vital to all the following processes:

- Metabolism, DNA building/repair/translation, signaling, transport, defense, and immunity.

How are proteins made?

The central biological doctrine is that genes code for proteins. DNA is transcribed into mRNA, which is then translated into proteins using ribosomes. **25,000** of our genes are protein coding, although this makes up only 1.5% of our entire genome. Also, proteins may have multiple functions, arise differently from the same gene, and may be modified so the 25,000 figure isn't really relevant - we have a huge variety of proteins.

Protein structure

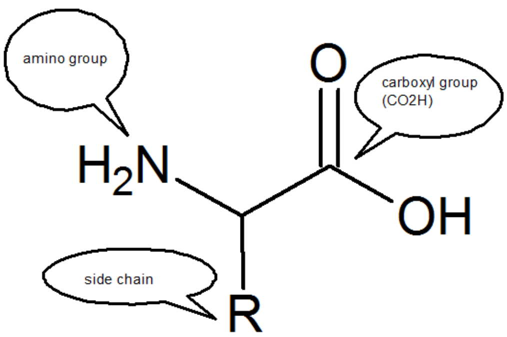
Proteins have a 3D structure with a great degree of flexibility that is formed through several distinct **stages** of development:

- *Primary* = the amino acid chain from the N to the C terminus.
- *Secondary* = the spatial arrangement of the main chain atoms. The most prominent secondary structures are alpha helices, and beta conformations.
- *Tertiary* = the overall 3D arrangement of all the atoms in the protein. This usually involves interactions between R groups to cause folding of the protein.
- *Quaternary* = the structure formed when two separate polypeptide chains join to form one protein.

Amino acid structure

The **basic structure** of all amino acids includes:

- R group that identifies the amino acid
- Carboxyl group
- Amino group



Amino acids form *peptide bonds* (dehydration reaction between carboxyl and amino groups) with one another to make polypeptide chains. Once inside the chain they are referred to as *amino acid residues*. Amino acids all have *zwitterionic* forms at neutral pH because they have a negatively charged carboxylate and a positively charged ammonia. Zwitterions have **two opposite charges that cancel out**.

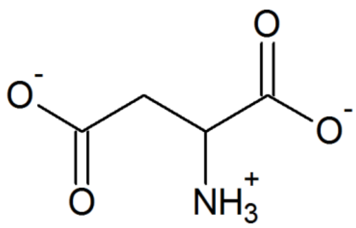
Grouping amino acids

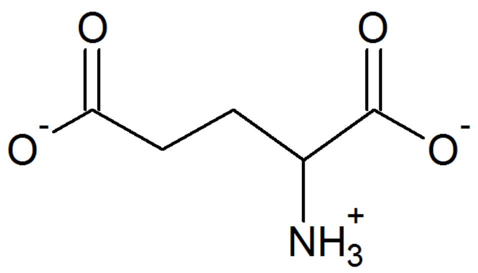
Amino acids can be classified (sometimes roughly) into groups based on the chemical properties of the R groups and their internal functional groups. The main classifications are: polar vs. non polar, hydrophilic vs. hydrophobic, aromatic vs. aliphatic, charged vs. non-charged.

Hydrophilic (charged, polar) amino acids (at a pH of 7):

Aspartate (or Aspartic Acid) [Asp, D]:

- Found in average frequency
- At pH=7 it has a carboxylate ion.
- pKa = 3.5 - acidic



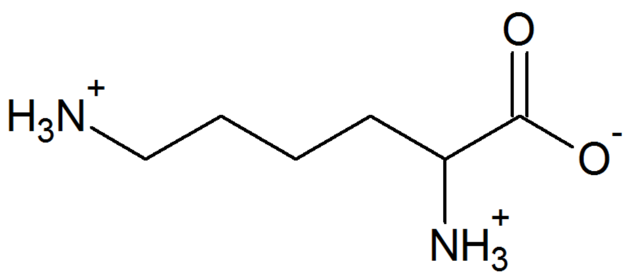


Glutamate (or Glutamic acid) [Glu, E]:

- Found at slightly above average frequency
- At pH=7 has carboxylate ion
- pKa = 4.5 - acidic

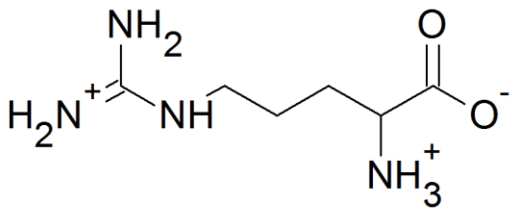
Lysine (Lys, K):

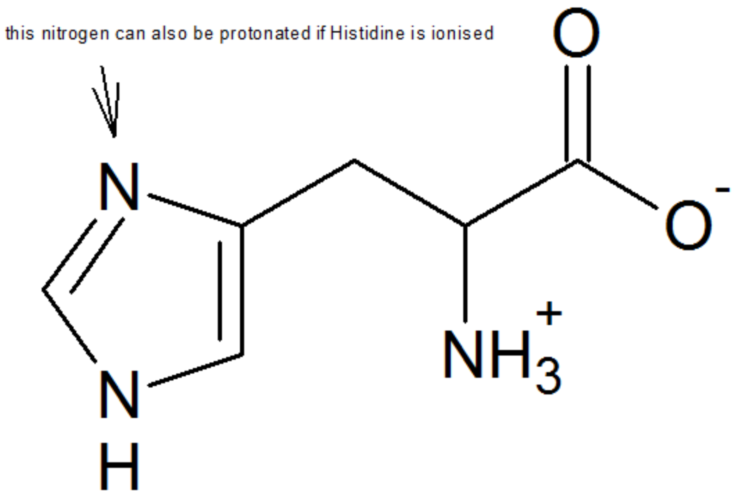
- Found in average frequency
- At pH=7 it has an ammonia
- pKa = 10.5 - basic
- Primary amine



Arginine (Arg, R):

- Found in average frequency
- At pH=7 it has a positively charged amino
- pKa = 12.5 - basic
- Possesses a guanidium group which is resonance stabilised and thus flat/planar.





Histidine (His, H):

- Quite rare in the body.
- At pH=7 it can be present ionised or not ionised.
- pKa = 6, mostly basic, sometimes acidic
- Has the ability to ligate to metal complexes when deprotonated.
- It contains an aromatic imidazole ring. It's thus flat and planar.