# Lecture 5: Amino Acids:

# A. Structure and Properties:

* An amino acid is a carboxylic acid with an amino group. Most biological amino acids are α-amino acids because the amino group is attached to the α-carbon.
* The "mainchain" or "backbone" atoms (N, Cα, C=O) are the same in each of the 20 commonly found amino acids.
* The sidechain atoms are unique to each amino acid and give rise to the unique properties of that amino acid.
* The sidechain atoms are designated with Greek letters, based on the nomenclature for carboxylic acids.
* The pKa of the carboxylate is ~2.0 and that of the amino group is ~9.0. Sidechain ionizable groups are also found on some amino acids.
* Amino acids are joined together to form linear polymers by the formation of a **peptide** **bond** between the carboxyl of one amino acids and the amino group of the next. This reaction releases water and is thus **dehydration** reaction.
* The peptide bond can be broken by the addition of water, a reaction called **hydrolysis** *(hydro-lysis)*.

**Expectations:**

* Full name of each (20) amino acid
* 3 Letter name of each amino acid
* Structure of each amino acid
* Properties of the side chains:

i) Ionization of groups (pKa)

ii) H-bonding capability

iii) Functional groups (polar/nonpolar)

* UV absorbance, calculation of protein concentration.

**B. Chirality & Optical Activity:** In all amino acids (except glycine) the α-carbon is chiral. In some amino acids, additional chiral centers are present. These are chiral centers because all four groups attached to the carbon are different. This means that the mirror images of these compounds cannot be superimposed. The two mirror images are called ***enantiomers***.

Enantiomers have the following attributes:

* *Identical* physical properties (except rotation of polarized light).
* Markedly *different* biological properties.
* Most common amino acids have an S configuration. An older, but very much used, notation is D and L. This notation is based on the chirality of a reference compound and **all amino acids that are found in proteins are L.**

**Importance of chirality in Biology:** Usually only one enantiomer is active in biological systems. As indicated above, only L-amino acids are used to make proteins. Amino acids of the other enantiomer (D) are generally harmless. This is not always the case for other compounds with chiral centers:

**Thalidomide**. This drug was prescribed as a sedative in the late 50s and early 60s. It was withdrawn because it causes birth defects by interfering with the development of the baby (**teratogens)**. This activity is associated with only one enantiomer. The other enantiomer is safe.

**C. Acid-Base Behavior of Proteins:**

Other sidechain ionizations: Tyr-OH pKa=10, Cys-SH, pKa=8.

Which groups don’t ionize at physiological pH ranges?

**D. Charge Calculations:**

The overall charge on a molecule as a function of pH can be calculated by summing the contribution from each ionizable group:

i) Identify all ionizable groups on the molecule & their charge when protonated and deprotonated.

ii) Use the known pKa of each group to determine the fraction protonated (fHA) and deprotonated (fA-) at the required pH.

iii) Calculate the overall charge by summing the contribution of each group.

**Example**: What is the net charge on glycine at pH=8?

**Zwitterion**: a compound that is ionized, but has no *net* charge**.**

**Isoelectric pH** = pI = pH where the net charge is zero.

**E. UV Absorption Properties of Amino Acids**

Three aromatic amino acids absorb light in the long wavelength ultraviolet range (UV).



The extinction coefficients (or molar absorption coefficients) of these amino acids are:

|  |  |  |
| --- | --- | --- |
|  | **Amino acid** | **Extinction Coefficient ε(λMAX)** |
| Trp |  5,500 M-1cm-1 (280 nm) |
| Tyr | 1,490 M-1cm-1 (274 nm~280nm) |
| Phe |  ~0 M-1cm-1 (280 nm) |

The amount of light absorbed by a solution of concentration [X] is given by the Beer-Lambert Law:

where

A is the absorbance of the sample;

I0 is the intensity of the incident light;

I is the intensity of the light that leaves the sample.

ε is the molar extinction coefficient at a specific wavelength at λmax. It is the amount of light absorbed by a 1M solution of the compound

[X]is the concentration of the absorbing species

*l* is the path length (usually 1 cm).*Therefore, given an extinction coefficient it is possible to measure the concentration of a protein.*

**Calculation of molar extinction coefficients:** If a molecule contains a mixture of N different chromophores, the molar extinction coefficient can generally be calculated as the sum of the molar extinction coefficient for each absorbing group in the protein:



Therefore, the molar extinction coefficient for a protein can be calculated from its amino acid composition.

**Example**:

i) A protein has two Tryptophan (Trp) residues and one Tyrosine (Tyr) what is its extinction coefficient?

ii) The absorption of a solution of the protein is 0.5 with a path length of 1 cm. What is the concentration of the protein?



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| **Functional Group** | **Structure** | **Amino Acids** | **Function.** |
| Non-polar, non aromatic | -CH3 (Ala) | Alanine, Valine, Isoleucine, Leucine | Protein folding – hydrophobic effect. Binding non-polar drugs. |
| Non-polar, aromatic | C:\Users\oli\Desktop\bio_two\quiz_image\fg_benzyl.png | Phenylalanine | Protein folding – hydrophobic effect. Binding non-polar drugs. |
| Alcohol | -OH | Serine, Threonine, Tyrosine | H-bond formation to drugs, other sidechains. |
| Carboxylate | C:\Users\oli\Desktop\bio_two\quiz_image\fg_carboxylate.png | Aspartic acidGlutamic acid | Usually ionized, neg. charge |
| Amide | amide.png | Aspargine Glutamine | H-bond formation, donor (NH) and acceptor (C=O). Note the NH cannot accept a H-bond. |
| Amino | C:\Users\oli\Desktop\bio_two\quiz_image\fg_amino.png | Lysine | Usually protonated, pos. charge. |
| Thiol (sulfhydral) | -SH | Cysteine | Forms disulfide bonds |