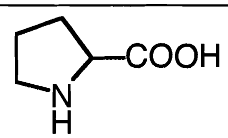
Amino acids are so called because they have both amino and acid groups in the same molecule. The biologically important ones are α-amino acids; i.e., both functional groups are bonded to the same carbon. The general structure is:

$$H_2N-\overset{*}{C}H-COOH$$
$$\quad\;\; R$$

The asterisk indicates that when R is not a hydrogen atom, the molecule is chiral. Some common amino acids are given in the table below:

R	Structure	Name	Abbreviations
-H	$H_2N\text{-}CH_2\text{-}COOH$	glycine	Gly G
$-CH_3$	$H_2N-CH-COOH$ CH_3	alanine	Ala A
$-CH_2$-Phenyl	$H_2N-CH-COOH$ $CH_2\text{-}C_6H_5$	phenylalanine	Phe F
$-CH(CH_3)_2$	$H_2N-CH-COOH$ $CH_3-CH\text{-}CH_3$	valine	Val V
$-CH_2$-OH	$H_2N-CH-COOH$ $CH_2\text{-}OH$	serine	Ser S
cyclic		proline	Pro P

The above is only a partial list of the about 20 amino acids which commonly occur in living systems. All natural amino acids have the same absolute configuration (by a Fischer convention they are in the L-series).

Because the amino acids contain both amino groups (bases) and carboxyl groups (acids) a proton can be transferred from –COOH to $-NH_2$. The compound containing a carboxylate anion and an ammonium cation is called a zwitterion (German: ion of both kinds).

$$\underset{\text{amino acid}}{H_2N\text{-}CH_2\text{-}COOH} \rightleftharpoons \underset{\text{zwitterion}}{H_3\overset{+}{N}\text{-}CH_2\text{-}COO^-}$$

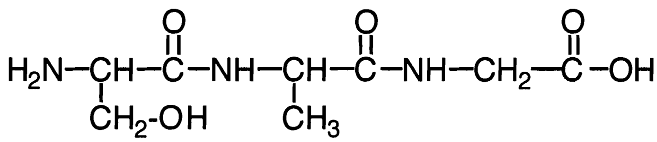
Amino acids can combine to form **<u>amides</u>** called **<u>peptides</u>**. The –<u>CO-NH</u>- bond or linkage is called the peptide bond. Formation of a peptide bond by loss of water from two amino acids is illustrated below:

$$H_2N\text{-}CH_2\text{-}COOH + H_2N\text{-}CH_2\text{-}COOH \xrightarrow{\text{- water}} H_2N\text{-}CH_2\text{-}\underline{CO\text{-}NH}\text{-}CH_2\text{-}COOH$$

Two amino acids form a <u>di</u>peptide, three amino acids a <u>tri</u>peptide, and many amino acids a <u>poly</u>peptide. Polypeptides involving more than about 100 amino acids are called **proteins** (from the Greek: *proteo*: I occupy first place; recall *pro*pionic acid comes from "<u>first</u> fat"). These are the first or primary substances in life: no life is known without them.

The exact nature (and function) of proteins is determined by the amino acids present and the order they occur. Simple examples are the tripeptides made by combining either three glycine molecules or two glycines and one alanine. The three glycine tripeptide can have only one structure: glycine-glycine-glycine. The other tripeptides can have different orders: glycine-alanine-glycine, glycine-glycine-alanine, and alanine-glycine-glycine. Each is a distinct molecule.

The convention for writing a peptide is to start with the **amino** group on the **left** and to end with the **acid** group on the **right** of the peptide. The tripeptide with the sequence, serine-alanine-glycine, would be written:



or drawn as zwitterion

and would be named seryl-alanyl-glycine (Ser-Ala-Gly).

It is clear that when 100 or more amino acids are involved and each of these may have one of 20 different structures, the number of possible proteins is huge. Some commonly occurring peptides are antibiotics, **hormones**, and **enzymes**. Besides many enzymes, albumin and histones are important examples of proteins. Another important category are the **fibrous proteins** which are of three types represented by: (1) the **silks**, (2) the **keratins** of skin, wool, claws, horn, scales, and feathers; and (3) the **collagens** of tendons and hides.

Peptide structures are determined by a combination of techniques including: (1) quantitative hydrolysis and assay of the amino acids present, (2) terminal amino acid analysis (and stepwise removal of amino acids from the amino and carboxyl ends of the peptide chemically or with enzymes) and (3) partial hydrolysis to smaller peptides (chemically or with enzymes) which are then assayed.

Consider partial hydrolysis:

Suppose you have a hexapeptide with contains (by quantitative hydrolysis and assay) one each of the following amino acids: **Ala**, **Gly**, **Phe**, **Pro**, **Ser**, and **Val**.

Four smaller peptides are isolated on partial acid hydrolysis. These are:

Phe-Val-Ser Gly-Ala Ala-Phe and Val-Ser-Pro.

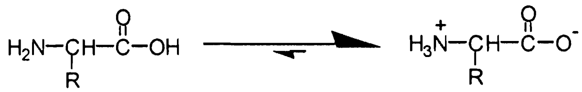
Then the structure of the peptide must be:

Val-Ser-Pro
Phe-Val-Ser
Ala-Phe
Gly-Ala

or **Gly-Ala-Phe-Val-Ser-Pro** (glycylalanylphenylalanylvalylserylproline)

Again by convention, Gly has the free amino group (it is on the left) and Pro has the free carboxyl group (it is on the right).

α-Amino Acids, Peptides, and Proteins

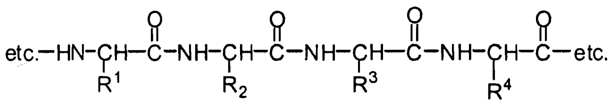


Because they have both an acidic (carboxyl) and a basic (amino) group, amino acids exist in an internal salt (zwitterionic) structure at ca. neutral pH.

There are about 20 important natural amino acids (different Rs).

Chiral amino acids all have the same configuration [**S** (old L)].

Peptides and Proteins:



Small Peptides:

e.g.: some hormones, oxytocin, vasopressin bradykinin (a pain molecule)

(Aspartame is L-Asp-L-Phe-OCH_3)

Medium Peptides:

e.g.: ACTH (39), Glucagon (28), Insulin (52)

Large Peptides (small proteins):

e.g.: Human growth hormone (180+)

HEXAPEPTIDE STRUCTURE ANALYSIS

Amino Acid Analysis Gives:

1 Ala	1 Ser	1 Leu
2 Gly	1 Val	

Partial Acid Hydrolysis Gives Smaller Peptides:

Leu-Gly-Val	Ser-Leu
Ala-Gly	Gly-Ser

What is Amino Acid Sequence in Peptide?

Which end is free amino group? free carboxyl?

PROTEINS

ENZYMES

e.g.: Lysozyme, Ribonuclease, Hemoglobin, Carboxypeptidase, Trypsin, Chymotrypsin, etc.

FIBROUS PROTEINS

1. the **SILK**S
2. the **KERATIN**S
   Skin, **Wool**, Claws, Horns, Scales, Feathers
3. the **COLLAGENS**
   Tendons and Hides

OTHERS

e.g., ALBUMIN

HISTONES (water soluble, basic)

SOY PROTEIN (from beans, etc.)

(tell the foam story)