The general formula of an amino acid is

\[ \text{H}_2\text{N}-\text{COOH} \]

\( R \) is commonly one of 20 different side chains. At pH 7 both the amino and carboxyl groups are ionized.

α-carbon atom

amino group

\( \text{H}_2\text{N} \)

\( \text{H}_2\text{O} \)

\( \text{COOH} \)

<table>
<thead>
<tr>
<th>Lysine</th>
<th>Arginine</th>
<th>Histidine</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lys, or K)</td>
<td>(Arg, or R)</td>
<td>(His, or H)</td>
</tr>
</tbody>
</table>

These nitrogens have a relatively weak affinity for an \( \text{H}^+ \) and are only partly positive at neutral \( \text{pH} \).

These 20 amino acids are given both three-letter and one-letter abbreviations. Thus: alanine = Ala = A

The α-carbon atom is asymmetric, allowing for two mirror-image (or stereo-) isomers, \( \text{L} \) and \( \text{D} \).

Proteins consist exclusively of \( \text{L} \)-amino acids.

Amino acids are commonly joined together by an amide linkage, called a peptide bond. The four atoms in each peptide bond (gray box) form a rigid planar unit. There is no rotation around the C–N bond.

Proteins are long polymers of amino acids linked by peptide bonds, and they are always written with the N-terminus toward the left. The sequence of this tripeptide is histidine-cysteine-valine.
ACIDIC SIDE CHAINS

- **Aspartic acid** (Asp, or D)
- **Glutamic acid** (Glu, or E)

![Chemical structures of aspartic acid and glutamic acid]

UNCHARGED POLAR SIDE CHAINS

- **Asparagine** (Asn, or N)
- **Glutamine** (Gln, or Q)

![Chemical structures of asparagine and glutamine]

Although the amide N is not charged at neutral pH, it is polar.

- **Serine** (Ser, or S)
- **Threonine** (Thr, or T)
- **Tyrosine** (Tyr, or Y)

![Chemical structures of serine, threonine, and tyrosine]

The –OH group is polar.

NONPOLAR SIDE CHAINS

- **Alanine** (Ala, or A)
- **Valine** (Val, or V)

![Chemical structures of alanine and valine]

- **Isoleucine** (Ile, or I)
- **Leucine** (Leu, or L)

![Chemical structures of isoleucine and leucine]

Although the amide N is not charged at neutral pH, it is polar.

- **Glycine** (Gly, or G)
- **Alanine** (Ala, or A)
- **Valine** (Val, or V)

![Chemical structures of glycine, alanine, and valine]

Disulfide bonds can form between two cysteine side chains in proteins.

![Chemical structure of disulfide bond: \(-\text{CH}_2 - S - S - \text{CH}_2 -\)