Amino Acids

Tishk International University,

Education Faculty, Biology Dept,

Biochemistry, 1st Semester/W2

Learning objectives

- To understand:
  - the structural features of amino acids
  - the properties of amino acids
  - the classifications of amino acids

Functions of Amino acids

- More than 300 amino acids are found in nature but only 20 amino acids are standard and present in protein because they are coded by genes. Other amino acids are modified amino acids and called non-protein amino acids.
- The genetic code is basically a code for proteins made within cells. DNA is translated into RNA. Three bases (combinations of A, U, G, and C) code for an amino acid. In addition, there is more than one code for most amino acid (TAT, TAC for tyrosine).

- Amino acids all have the basic backbone. They all consist of a carbon atom (C) attached to a carboxyl group (-COOH), an amino group, (-NH_2), a Hydrogen, and another group of atoms (R).
- The R group gives the amino acid its unique characteristics, and allows it to react with other amino acids in unique ways.
- A variety of metabolism
  - Building bloks of proteins
  - Forming parts of coenzymes
  - As precursors for the biosynthesis of molecules such as heme

Structure of amino acids

- Proteins consists of amino acid linked to peptide bond,
- Each amino acid consists of:
  - Central carbon atoms
  - An amino group
  - Carboxyl group
  - H atom
  - Side chain
- Different side chain result in various amino acid

Stereochemistry of amino acids

Configuration

- The α carbon on all amino acids, except glycine, is a ***chiral carbon*** because it has four different groups bonded to it.
- Thus a-carbon atom is thus a chiral center.

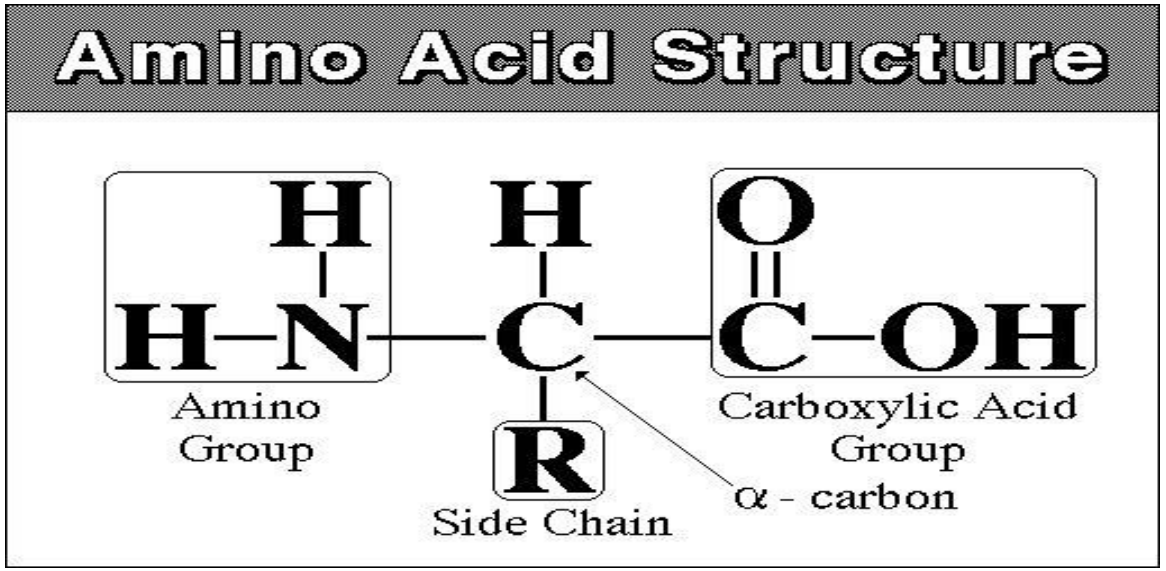


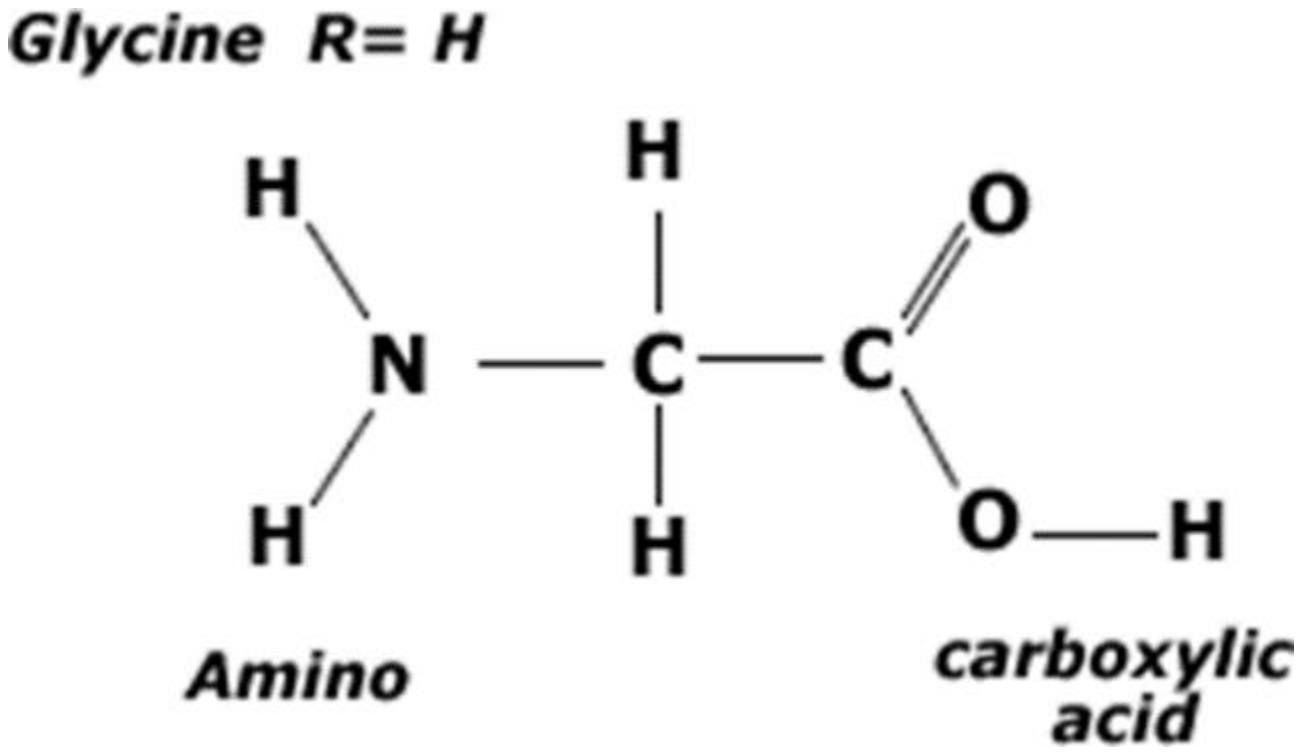
Table 3-2 Abbreviations for Amino Acids

Amino Acid	Three-Letter Abbreviation	One-Letter Abbreviation
Alanine	Ala	A
Arginine	Arg	R
Asparagine	Asn	N
Aspartate	Asp	D
Cysteine	Cys	C
Glutamate	Glu	E
Glutamine	Gln	Q
Glycine	Gly	G
Histidine	His	H
Isoleucine	Ile	I
Leucine	Leu	L
Lysine	Lys	K
Methionine	Met	M
Phenylalanine	Phe	F
Proline	Pro	P
Serine	Ser	S
Threonine	Thr	T
Tryptophan	Trp	W
Tyrosine	Tyr	Y
Valine	Val	V

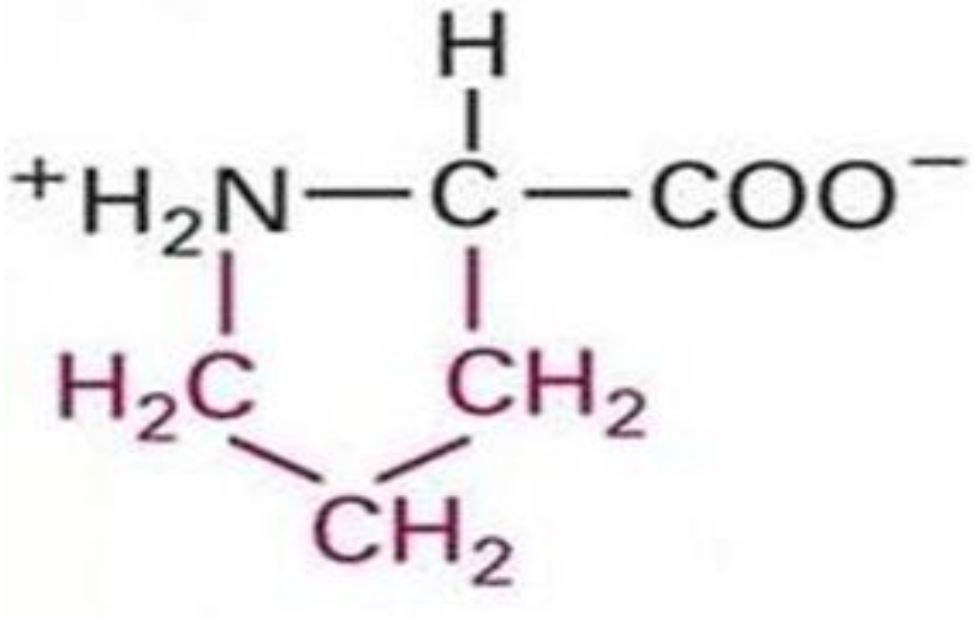
Figure: above are the names of the 20 amino acids. Each amino acid has a three letter designation as well as a single letter designation.

- Glycine :

Is simple amino acid because R chain is H

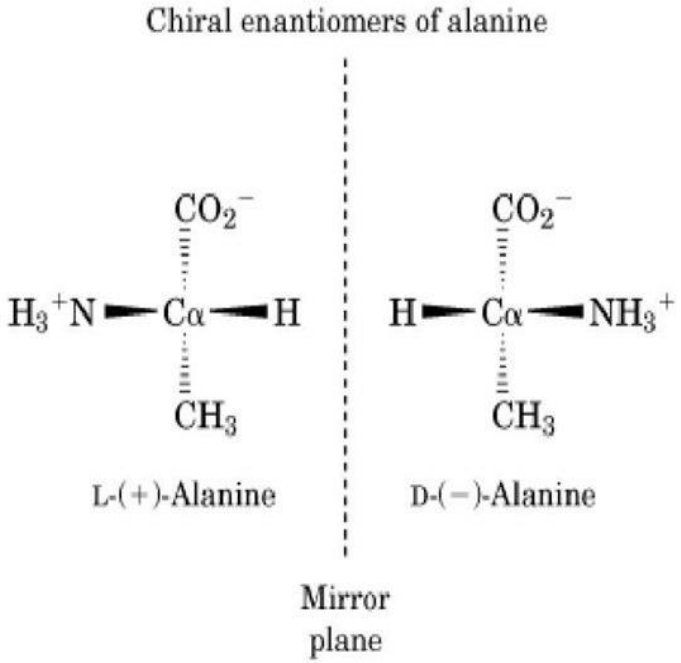


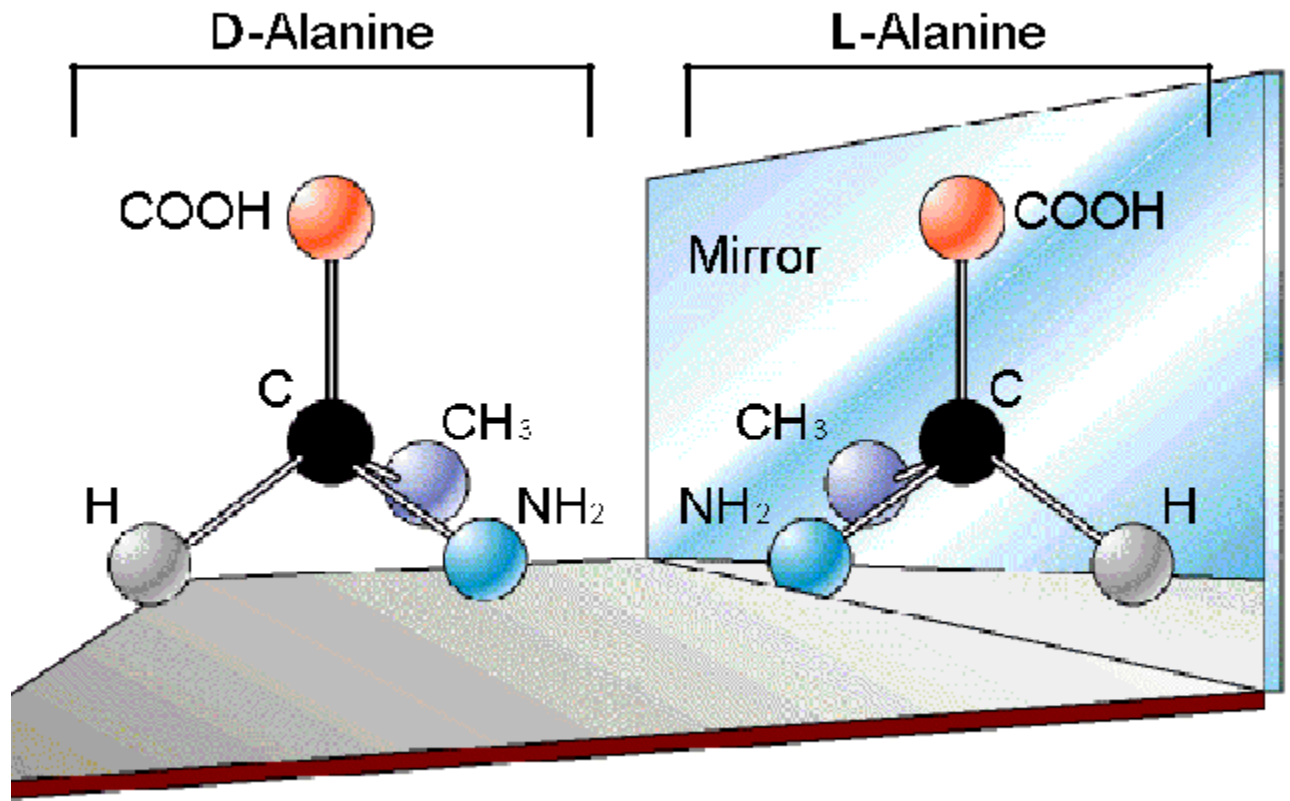
- Proline
- It is unique among the 20 protein-forming amino acids in that the amine nitrogen is bound to not one but two alkyl groups, thus making it a secondary amine



- This chiral center allows for stereoisomerism. The amino acids form two stereoisomers that are mirror images of each other. The structures are not superimposable on each other, much like your left and right hands. These mirror images are termed enantiomers.
- There are two important nomenclature systems for enantiomers.
- The D/L system is based on optical activity and refers to the Latin words *dexter* for right and *laevus* for left, reflecting left- and right-handedness of the chemical structures.
- An amino acid with the dexter configuration (dextrorotary) would be named with a (+) or D prefix, such as (+) serine or D-serine.
- An amino acid having the laevus configuration (levorotary) would be prefaced with a (-) or L, such as (-) serine or L-serine.

- How to determine whether an amino acid is the D or L enantiomer?
- If the amine group is located on the right side of the carbon chain, the compound is D. If the amine group is on the left side, the molecule is L.
- Only the L-amino acids have been found in proteins.
- D-isomers have been found only in small peptides of bacteria cell walls or in some peptide antibiotics.

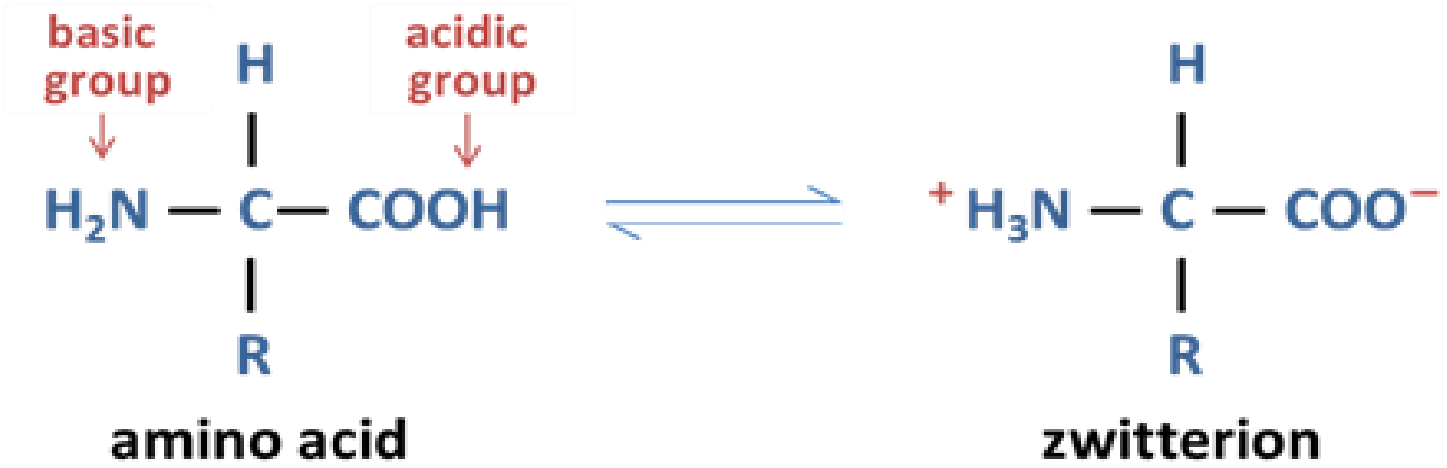




(Karp 1997)

Zwitterions and Amino Acids

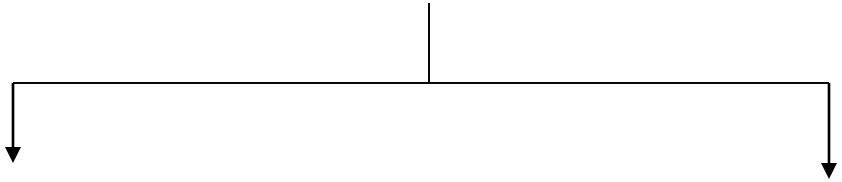
- A zwitterion is a molecule with functional groups, of which at least one has a positive and one has a negative electrical charge. The net charge of the entire molecule is zero.
- Amino acids are the best-known examples of zwitterions. They contain an amine group (basic) and a carboxylic group (acidic). The -NH_2 group is the stronger base, and so it picks up H^+ from the -COOH group to leave a zwitterion (i.e. the amine group de-protonates the carboxylic acid).



- The structure of an amino acid allows it to act as both an acid and a base.
- An amino acid has this ability because at a certain pH value (different for each amino acid) nearly all the amino acid molecules exist as zwitterions.
- Zwitterions are dipole ions—meaning that these molecules have two charges, both a positive and a negative charge.
- If acid is added to a solution containing the zwitterion, the carboxylate group captures a hydrogen (H^+) ion (protonated), and the amino acid becomes positively charged.
- If base is added, ion removal of the H^+ ion from the amino group of the zwitterion produces a negatively charged amino acid (deprotonated).
- In both circumstances, the amino acid acts to maintain the pH of the system—that is, to remove the added acid (H^+) or base (OH^-) from solution.

- The charged state of an amino acid in aqueous solution depends largely on the pH.
- The particular pH at which a given amino acid exists in solution as a zwitterion is called the isoelectric point (pI).
- At its pI, the positive and negative charges on the amino acid balance, and the molecule as a whole is electrically neutral.
- At this pH, the amount of positive charge balances that of negative charge and the concentration of the charge-neutralized zwitterionic form is at its highest.

Classification of Amino Acids



Nutritional

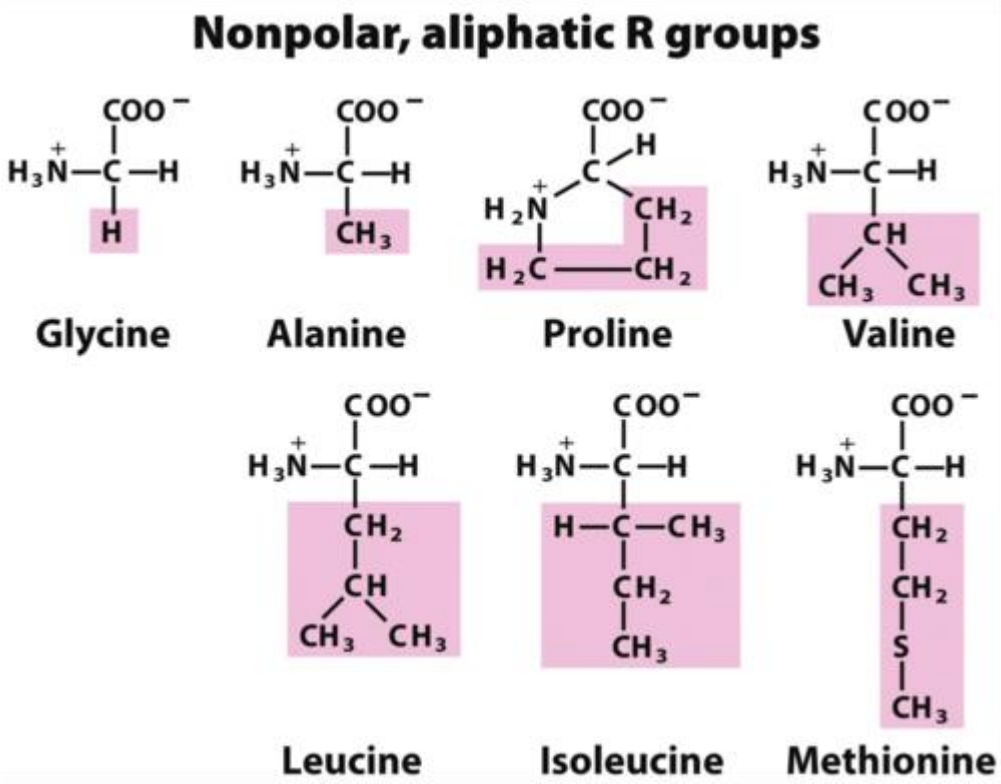
- Essential
- Non-essential

Based on R group

- Non polar aliphatic R group
- Aromatic R group
- Polar uncharged R group
- Positively charged R group
- Negatively charged R group

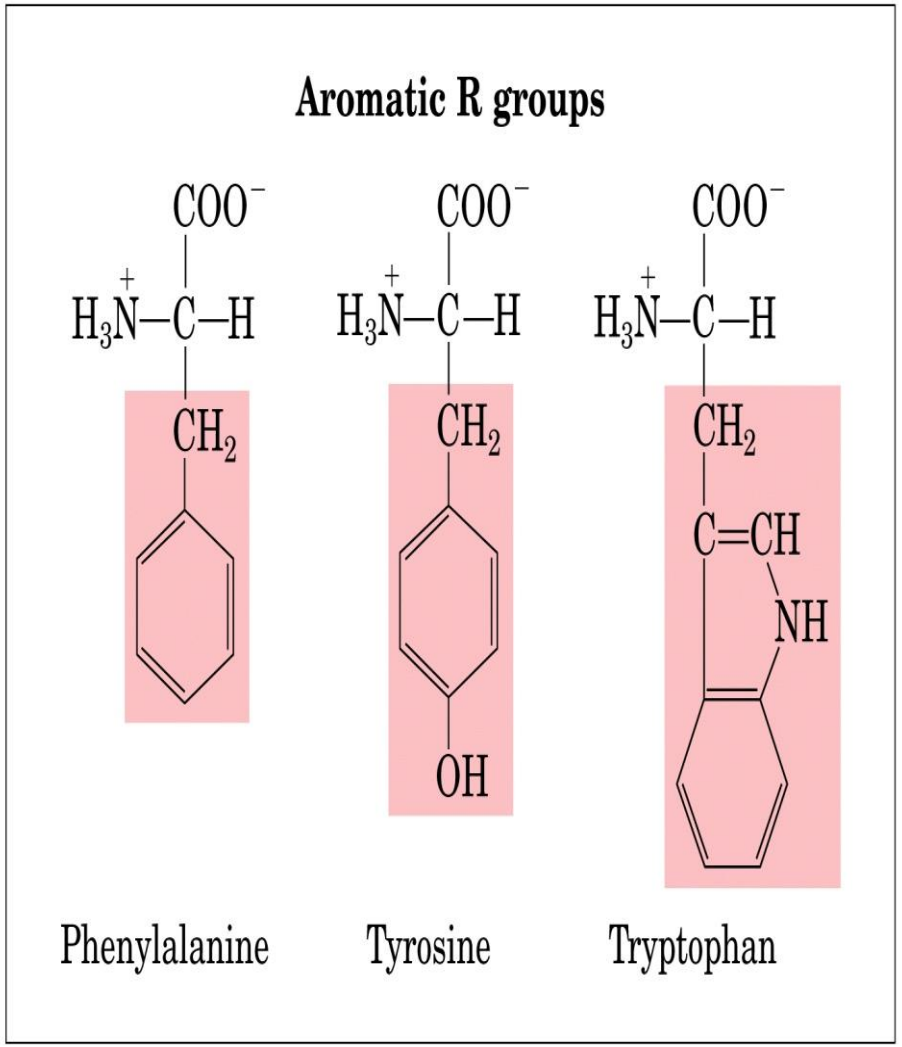
1) Nonpolar, Aliphatic Amino Acids

- The hydrocarbon R group in this class of amino acids is nonpolar and hydrophobic.
- Glycine has the simplest amino acid structure.
- The bulky side chain of valine, isoleucine and leucine are important in promoting hydrophobic interactions within protein structures.



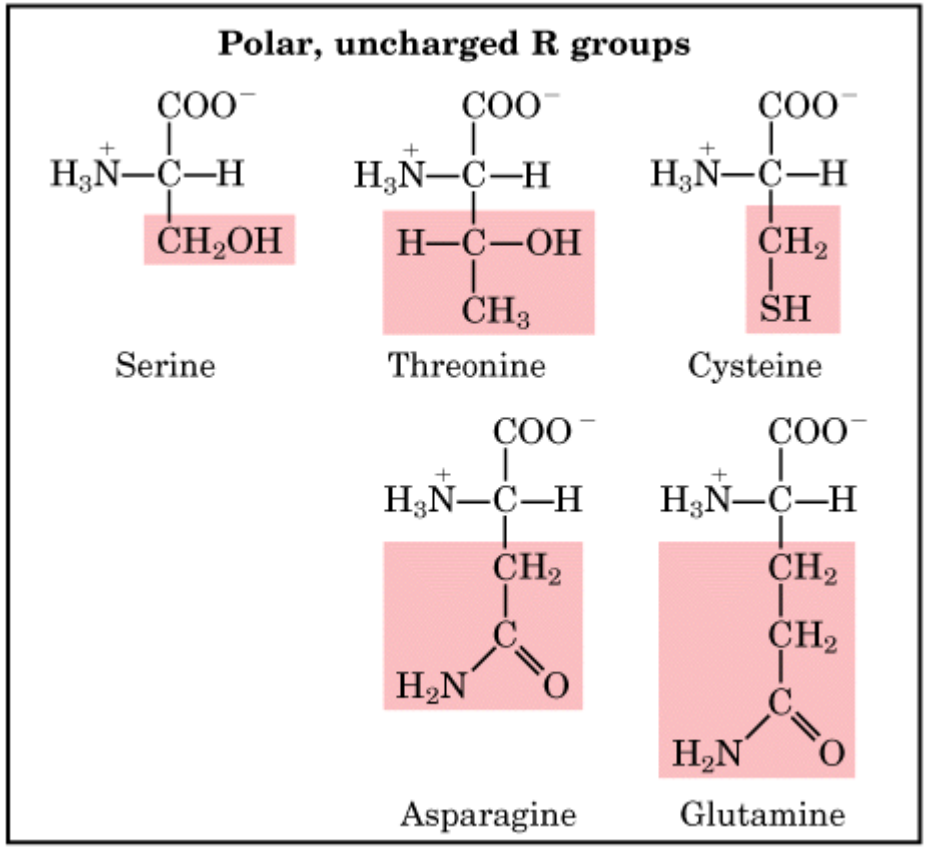
2) Aromatic Amino Acids

- Their aromatic side chains are relatively nonpolar.
- All can participate in hydrophobic interactions.
- The OH group of tyrosine can form hydrogen bond and can act as an important functional group in the activity of some enzymes.



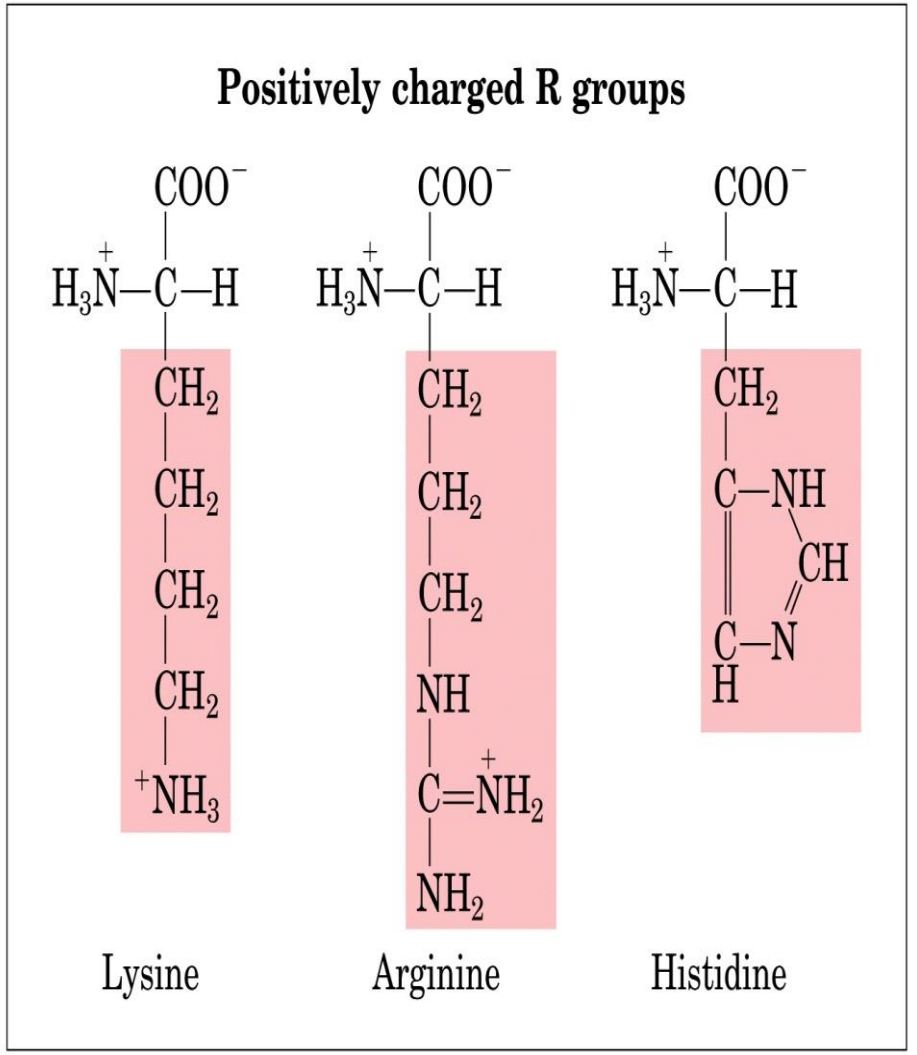
3) Polar Amino Acids

- The R group of these amino acids is more soluble in water, or hydrophilic than those of non polar amino acids, because they contain functional groups that form hydrogen bond with water.



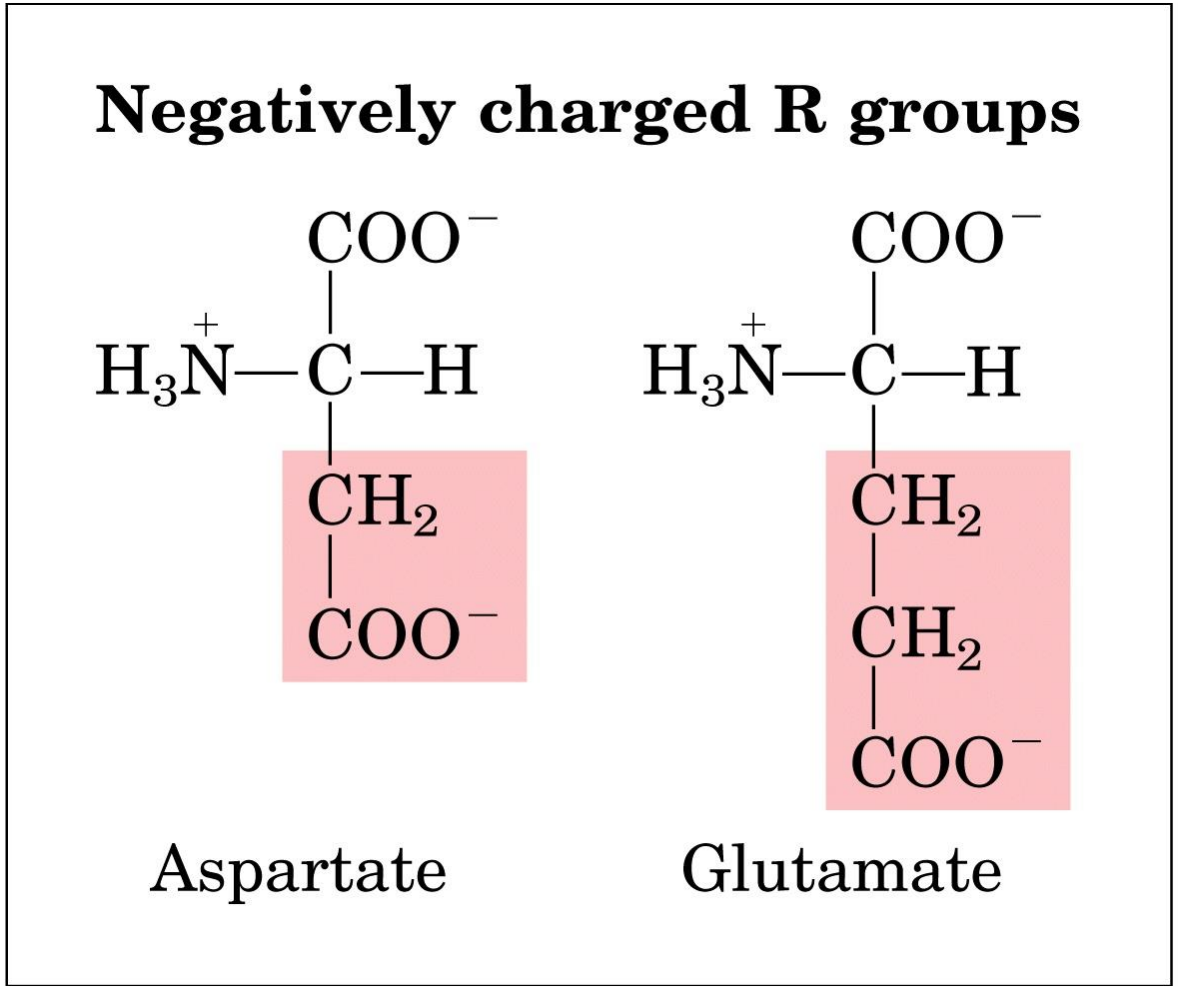
4) Positively Charged Amino Acids

- The amino acids in which the R group have a net positive charge at pH 7.0



5) Negatively Charged Amino Acids

- Amino acids having R group with a net negative charge at pH 7.0, with a second carboxyl group



Essential, Nonessential, and Conditional

- Essential – cannot be made by body, must be consumed in the diet
- Nonessential – can be synthesized in the body
- Conditionally essential – cannot be synthesized due to illness or lack of necessary precursors
  - Premature infants lack sufficient enzymes needed to create arginine

Table 6.1

The Mighty Twenty

Essential Amino Acids	Nonessential Amino Acids
Histidine (His)[a]	Alanine (Ala)
Isoleucine (Ile)	Arginine (Arg)[b]
Leucine (Leu)	Asparagine (Asn)
Lysine (Lys)	Aspartic acid (Asp)
Methionine (Met)	Cysteine (Cys)[b]
Phenylalanine (Phe)	Glutamic acid (Glu)
Threonine (Thr)	Glutamine (Gln)[b]
Tryptophan (Trp)	Glycine (Gly)[b]
Valine (Val)	Proline (Pro)[b]
	Serine (Ser)
	Tyrosine (Tyr)[b]

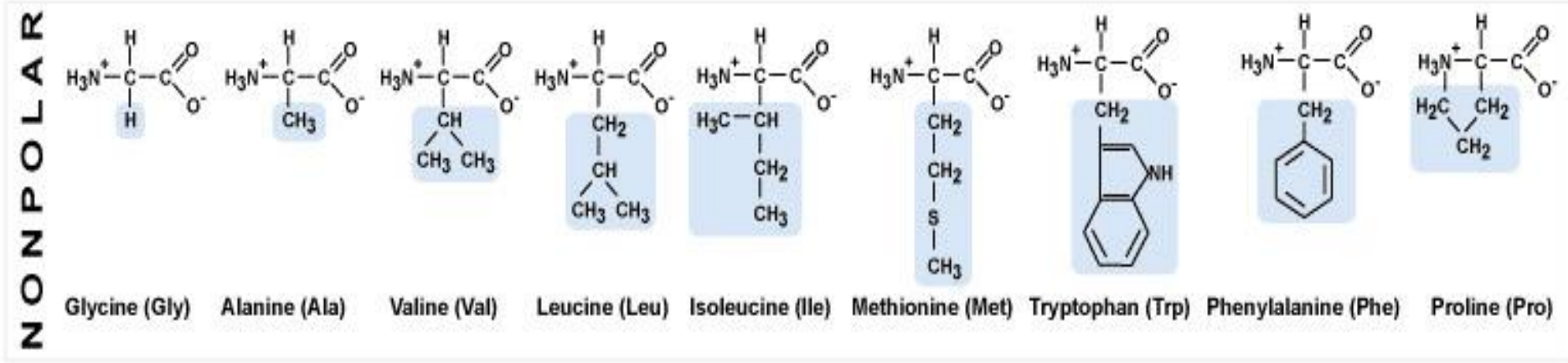
[a] Histidine was once thought to be essential only for infants. It is now known that small amounts are also needed for adults.

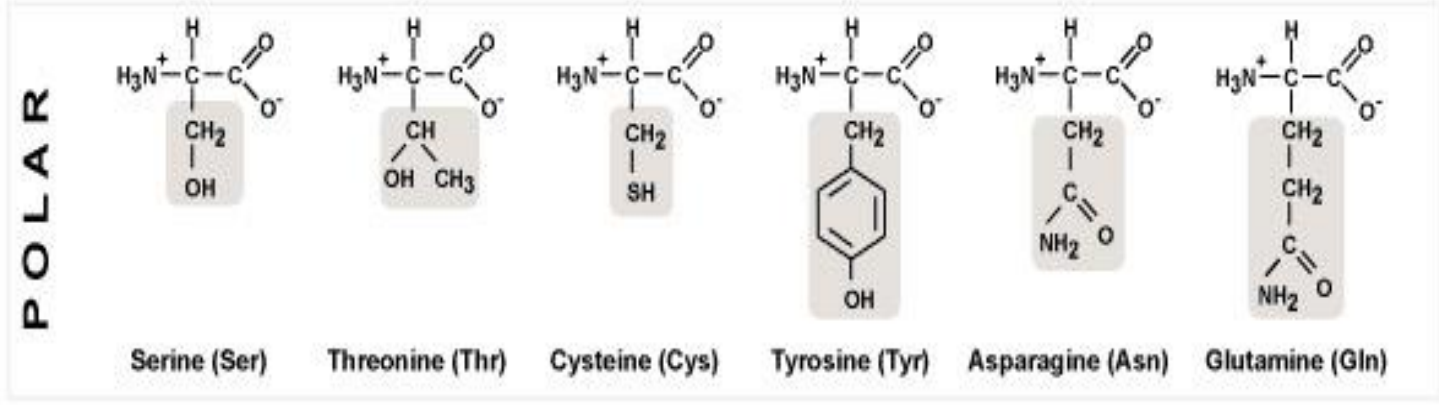
[b] These amino acids can be "conditionally essential" if there are either inadequate precursors or inadequate enzymes available to create these in the body.

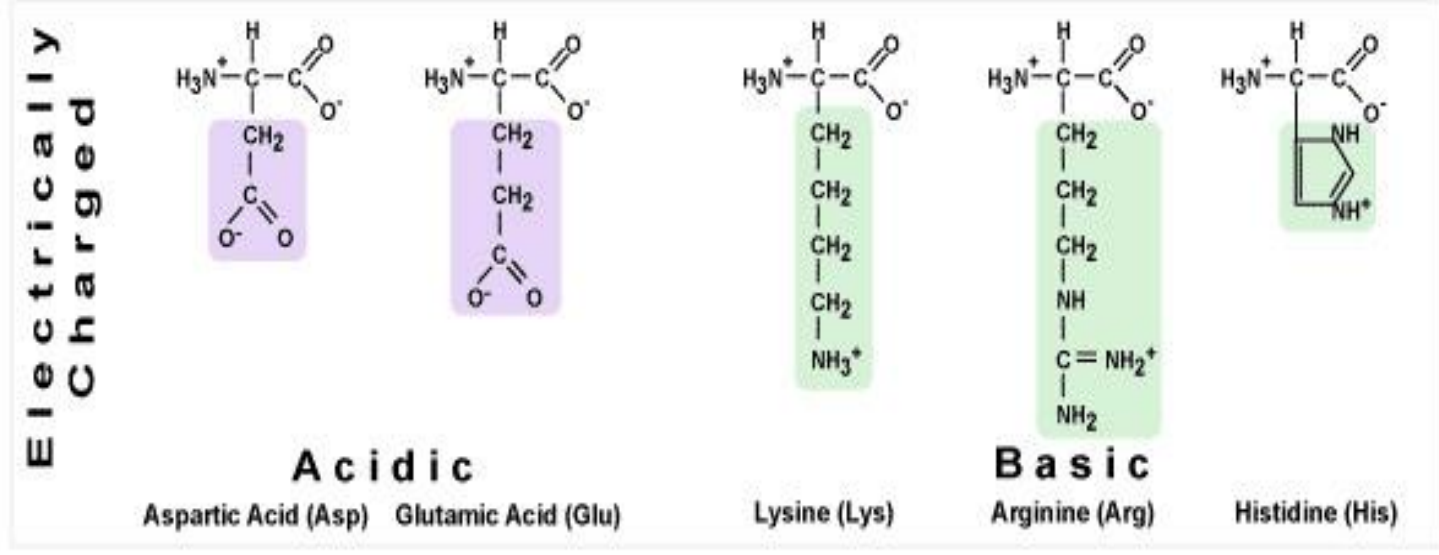
Essential Amino Acids

- **Phenylalanine:** Phenylalanine is a precursor for the neurotransmitters tyrosine, dopamine, epinephrine and norepinephrine. It plays an integral role in the structure and function of proteins and enzymes and the production of other amino acids.
- **Valine:** Valine is one of three branched-chain amino acids, meaning it has a chain branching off to one side of its molecular structure. Valine helps stimulate muscle growth and regeneration and is involved in energy production.
- **Threonine:** Threonine is a principal part of structural proteins such as collagen and elastin, which are important components of the skin and connective tissue. It also plays a role in fat metabolism and immune function.
- **Tryptophan:** Though often associated with causing drowsiness, tryptophan has many other functions. It's needed to maintain proper nitrogen balance and is a precursor to serotonin, a neurotransmitter that regulates your appetite, sleep and mood.
- **Methionine:** Methionine plays an important role in metabolism and detoxification. It's also necessary for tissue growth and the absorption of zinc and selenium, minerals that are vital to your health.

- **Leucine:** Like valine, leucine is a branched-chain amino acid that is critical for protein synthesis and muscle repair. It also helps regulate blood sugar levels, stimulates wound healing and produces growth hormones.
- **Isoleucine:** The last of the three branched-chain amino acids, isoleucine is involved in muscle metabolism and is heavily concentrated in muscle tissue. It’s also important for immune function, hemoglobin production and energy regulation.
- **Lysine:** Lysine plays major roles in protein synthesis, hormone and enzyme production and the absorption of calcium. It’s also important for energy production, immune function and the production of collagen and elastin.
- **Histidine:** Histidine is used to produce histamine, a neurotransmitter that is vital to immune response, digestion, sexual function and sleep-wake cycles. It’s critical for maintaining the myelin sheath, a protective barrier that surrounds your nerve cells.







Amino Acids
NOTE: You need to know this table

AMINO ACID			SIDE CHAIN
Aspartic acid	Asp	D	negative
Glutamic acid	Glu	E	negative
Arginine	Arg	R	positive
Lysine	Lys	K	positive
Histidine	His	H	positive
Asparagine	Asn	N	uncharged polar
Glutamine	Gln	Q	uncharged polar
Serine	Ser	S	uncharged polar
Theonine	Thr	T	uncharged polar
Tyrosine	Tyr	Y	uncharged polar

POLAR AMINO ACIDS

Hydrophilic

AMINO ACID			SIDE CHAIN
Alanine	Ala	A	nonpolar
Glycine	Gly	G	nonpolar
Valine	Val	V	nonpolar
Leucine	Leu	L	nonpolar
Isoleucine	Ile	I	nonpolar
Proline	Pro	P	nonpolar
Phenylalanine	Phe	P	nonpolar
Methionine	Met	M	nonpolar
Tryptophan	Trp	W	nonpolar
Cysteine	Cys	C	nonpolar

NONPOLAR AMINO ACIDS

Hydrophobic