

**AMINO ACIDS II:****CLASSIFICATION AND CHEMICAL CHARACTERISTICS OF EACH AMINO ACID:****Table 3.1****Table of abbreviations of the 20 amino acids found in proteins**

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

Table 3-1 Concepts in Biochemistry, 3/e  
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- The “R” group side chains on amino acids are **VERY important**.

○ Determine the properties of the amino acid itself

○ Determine the properties of the proteins that contain those amino acids; Dictate what a protein can and cannot do and how it folds.

○ Important to remember that biomolecules have three dimensions. It's this feature that dictates which reactions can take place in a cell.

- All 20 amino acids have both three letter and one letter abbreviations

- For example:  
Alanine (Ala, A)  
Cysteine (Cys, C)

- You are responsible for knowing the three letter and one letter codes and well as the structures of all 20 amino acids.

- **Groups classified by different properties**

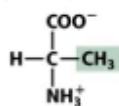
○ **I: Non-polar side chains (hydrophobic)**

○ **II: Polar, uncharged side chains**

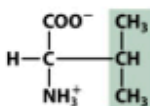
○ **III: Charged Side Chains**

○ **Acidic side chains**

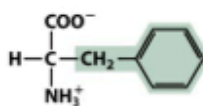
○ **Basic side chains**

**Hydrophobic amino acids**

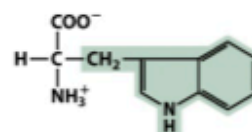
Alanine (Ala, A)



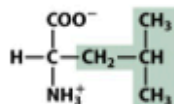
Valine (Val, V)



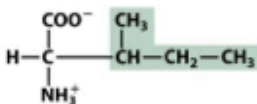
Phenylalanine (Phe, F)



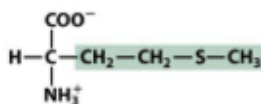
Tryptophan (Trp, W)



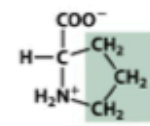
Leucine (Leu, L)



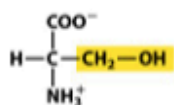
Isoleucine (Ile, I)



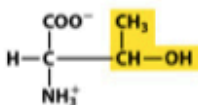
Methionine (Met, M)



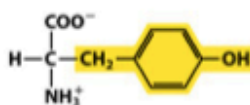
Proline (Pro, P)

**Polar amino acids**

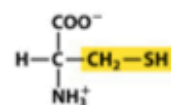
Serine (Ser, S)



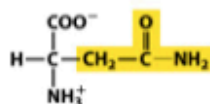
Threonine (Thr, T)



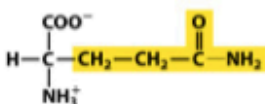
Tyrosine (Tyr, Y)



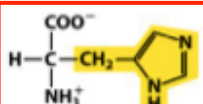
Cysteine (Cys, C)



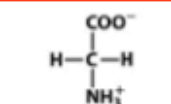
Asparagine (Asn, N)



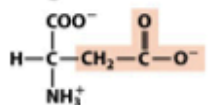
Glutamine (Gln, Q)



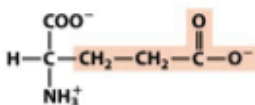
Histidine (His, H)



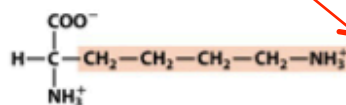
Glycine (Gly, G)

**Charged amino acids**

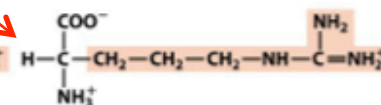
Aspartate (Asp, D)



Glutamate (Glu, E)



Lysine (Lys, K)



Arginine (Arg, R)

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**GROUP I: NON-POLAR (HYDROPHOBIC) SIDE CHAINS**

- Side chains of Group I aa's are mainly hydrocarbons – very unreactive amino acids
- 2 subgroups: Aliphatic hydrocarbons & Aromatic hydrocarbons (have benzene rings)
- These amino acids will tend to be buried (away from water) in 3-D structure of proteins
- Non-polar character

**1) ALIPHATIC HYDROCARBONS****a. Glycine (G, Gly)**

- R group is hydrogen
- Found in flexible parts of proteins
- Not chiral
- Can be modified by addition of a fatty acid (myristate – 14 Carbon)

**Table 3.3**

Classification of the amino acids based on side chain reactivity and polarity at pH 7.4

Group I, Hydrophobic	Group II, Polar, Uncharged	Group III, Polar, Charged
Gly	Ser	Asp
Ala	Thr	Glu
Val	Cys	Lys
Leu	Tyr	Arg
Ile	Asn	
Pro	Gln	
Met	His	
Phe		
Trp		

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**b. Alanine (A, Ala)**

- i. The model amino acid
- ii. R group is  $-\text{CH}_3$  (methyl group)

**c. Valine (V, Val)****Leucine (L, Leu)****Isoleucine (I, Ile)**

- Extended aliphatic chains
- Can be branched

**d. Methionine (M, Met)**

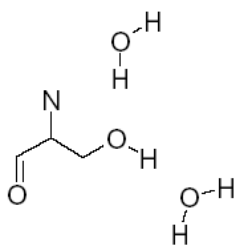
- i. Contains sulfur
- ii. Can interact and bind with metal ions
- iii. Often found in metalloproteins

**e. Proline (P, Pro)**

- i. Only imino acid
- ii. Affects protein folding
- iii. Often found at bends in protein 3-D structures
- iv. Hydroxylation of proline important for the structure of collagen

**2) AROMATIC HYDROCARBONS****a. Phenylalanine (F, Phe) and Tryptophan (W, Trp)**

- i. Fluorescent
- ii. UV absorbing at 250-300 nm – can be useful to identify proteins in a mixture
- iii. Tryptophan is converted to **serotonin** (5-hydroxytryptamine)
  - Serotonin has a sedative effect – gives a pleasant feeling
  - Very low levels of serotonin associated with depression
  - Extremely high levels produce a manic state

**GROUP II: NEUTRAL (UNCHARGED) POLAR SIDE CHAINS**

- **Polar Residues** are both buried as well as on the surface of proteins. They either form hydrogen bonds with other polar residues in the protein or with water. For example, the OH group of Serine can both donate as well as accept a hydrogen bond:

**Serine****a. Serine (S, Ser) and Threonine (T, Thr)**

- i. Polarity contributed by the hydroxyl group ( $-\text{OH}$ )
- ii. Sugars attach to Ser and Thr to form **glycoproteins**
- iii. Ser & Thr can have phosphates attached – regulates the activity of some proteins

**b. Tyrosine (Y, Tyr)**

- i. Fluorescent – absorbs UV light at 280nm (easy to identify)
- ii. Can be **phosphorylated** (have phosphates attached)
- iii. Derived from **phenylalanine**
- iv. Converted to **catecholamines** – includes epinephrine (adrenaline)
  - “fight or flight” hormone
  - causes release of glucose and other nutrients into the blood and stimulates brain function

- **Tyrosine, Serine, and Threonine**

- Can be **phosphorylated** on hydroxyl groups
- Phosphoserine, phosphotyrosine, phosphothreonine
- Involved in signal transduction pathways

**c. Asparagine (N, Asn) and Glutamine (Q, Gln)**

- i. Classified as **amides**
- ii. Neither acidic or basic
- iii. Forms H-bonds
- iv. Asn can be modified with sugars to form **glycoproteins**

**d. Cysteine (C, Cys)**

- i. Sulfhydryl side chain (-SH) (gives the polarity)
- ii. Cys can be modified by addition of farnesyl or geranylgeranyl groups
  1. Example – Required for membrane association of Ras proteins
- iii. Can oxidize to form **disulfide bonds** that strengthen protein structure
- iv. Disulfide bonds are **covalent but reversible** upon reduction

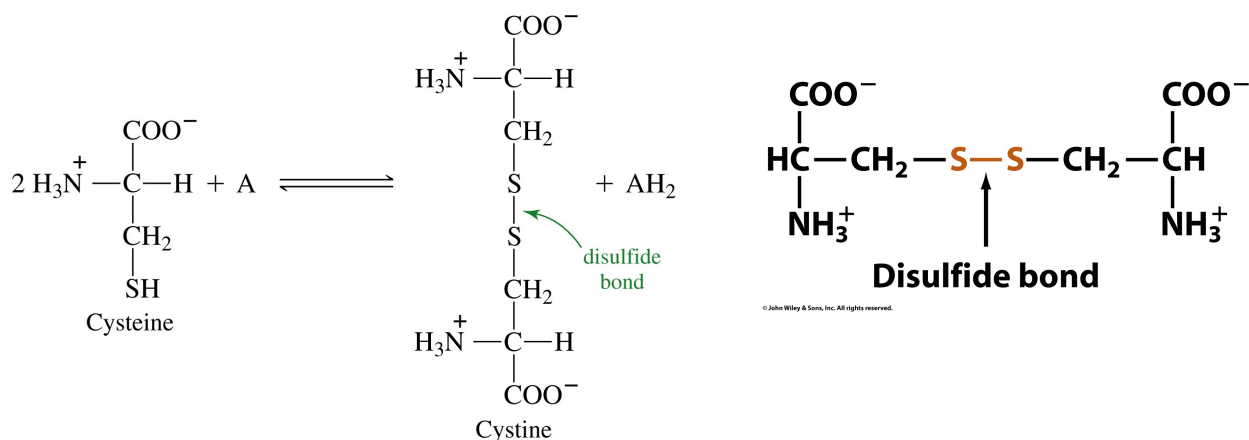
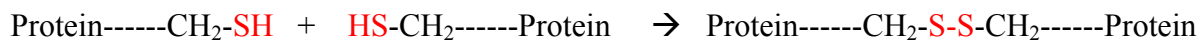


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**GROUP III: Charged Amino Acids****A. ACIDIC SIDE CHAINS**

- a. **Glutamate** or glutamic acid (**E, Glu**) and **Aspartate** or aspartic acid (**D, Asp**)

Always negatively charged at physiological pH (~7.4)

**B. BASIC SIDE CHAINS**

All gain a proton at physiological pH (Positively charged)

- a. **Lysine (K, Lys)**  
 b. **Arginine (R, Arg)**  
 c. **Histidine (H, His)**

His is ionizable near physiological pH; therefore can act as a proton donor OR acceptor depending on the pH in the local environment. ~50% protonated under physiological conditions

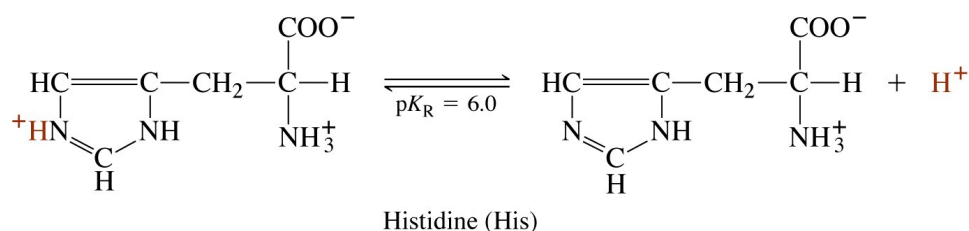


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**SUMMARY & SOME GENERAL RULES:**

- Charged, hydrophilic residues are hardly ever buried – tend to cluster on outside of a protein in water
- Polar residues are usually found on the surface of the protein, but can be buried.
- The inside, or core of a protein contains mostly non-polar, hydrophobic amino acids.
- Non-polar residues are also found on the outside of proteins.
- Recognition of one biological molecule by another (i.e. surface-surface contacts) can utilize charged, polar and non-polar interactions.

**OTHER AMINO ACIDS:**

- Some other amino acids are derivatized once incorporated into proteins

- **Hydroxyproline and hydroxylysine**

- Found in collagen, the principle component of connective tissue
- Proline and lysine modified after incorporation

- Modifications essential for maintaining normal connective tissues in tendons, cartilage, bones, teeth, skin

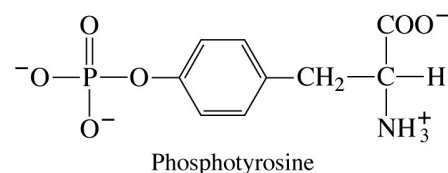
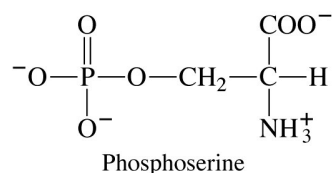
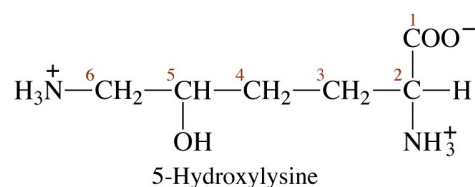
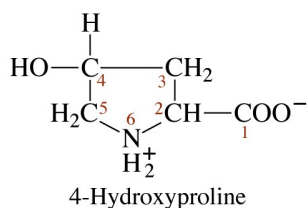
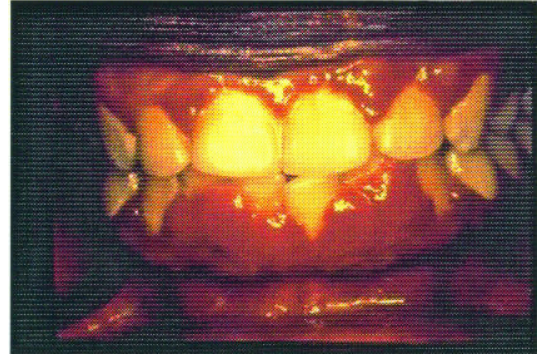


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○ **SCURVY: deficiency of vitamin C.**

- Vitamin C necessary for enzyme prolyl hydroxylase to make **hydroxyproline**. Also necessary for hydroxylysine production.
- Without Vitamin C – Scurvy results
- Inability to form collagen properly
- Anemia
- Lesions – skin and blood vessels
- Weakening of teeth, bone, cartilage, and connective tissues
- Advanced grotesque disfiguration, bleeding and death.



**EXAMPLES OF AMINO ACIDS IN THE NEWS:**

**L-Tryptophan**

- Biosynthetic precursor of serotonin, a brain chemical involved in regulating sleep, mood and appetite
- Health food industry marketed L-Tryptophan in the 1970's and 80's with no knowledge as to whether it worked or was safe
- In 1990, pulled from the market due to an outbreak of a rare blood disease called "Eosinophilia myalgia" (EMS). Out of 1500 cases reported, at least 37 deaths.
- Most likely due to a chemical contaminant that co-purified with it. Might also be due to excess L-Trp itself.
- Limited availability as mandated by FDA
- Reformulated new version = 5-hydroxyl-L-Trp is available but still has contaminant, albeit at a lower level.

**\*\*There is little to no regulation of "natural" nutritional supplements sold as medication.  
Be aware and be careful!!**

Under the Dietary Supplement Health and Education Act of 1994 (DSHEA), the dietary supplement or dietary ingredient manufacturer is responsible for ensuring that a dietary supplement or ingredient is safe before it is marketed.

FDA is responsible for taking action against any unsafe dietary supplement product after it reaches the market.

Generally, manufacturers do not need to register their products with FDA nor get FDA approval before producing or selling dietary supplements.

Manufacturers must make sure that product label information is truthful and not misleading.

The manufacturer, packer, or distributor whose name appears on the label of a dietary supplement marketed in the United States is required to submit to FDA all serious adverse event reports associated with use of the dietary supplement in the United States.

**MSG – MONOSODIUM GLUTAMATE**

- Sodium salt of amino acid glutamate
- Used as flavor enhancer
- May work to stimulate glutamate receptors in the tongue
- May have an influence on the nervous system, though this is not seen with eaten glutamate
- Some people react to MSG and develop “MSG Symptom Complex” – Symptoms include:
  - a. Burning in the back of the neck
  - b. Numbness in back of neck radiating to arms and back
  - c. Tingling, warmth and weakness in face, temples, upper back and arms
  - d. Headache
  - e. Nausea
  - f. Rapid heart rate
  - g. Bronchospasms in asthmatics
  - h. Drowsiness and weakness
- FDA does regulate that MSG must be labeled