

# **BIOCHEMISTRY**

# **AMINO ACIDS**

**PREPARED BY:**

**RAMYA.M,**

**DEPT OF BOTANY**

**LF COLLEGE, GURUVAYOOR**

**AMINO ACIDS** are organic compounds containing

❖ **AMINE GROUP(NH<sub>2</sub>)**

❖ **CARBOXYL GROUP (COOH)**

❖ **SIDE CHAIN (R GROUP)**

➤ **Building blocks of protein**

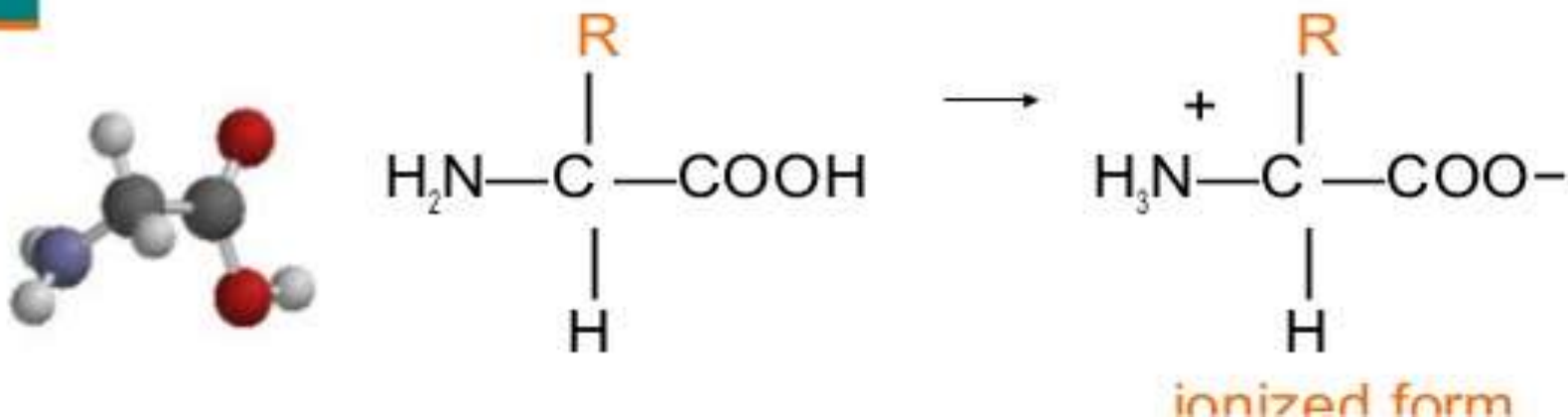
➤ **THE MAJOR KEY ELEMENT IN AMINO ACIDS IS CARBON , HYDROGEN, NITROGEN, OXYGEN**

➤ **About 500 amino acids are known among them only 20 appear in genetic code it is known as magic 20**

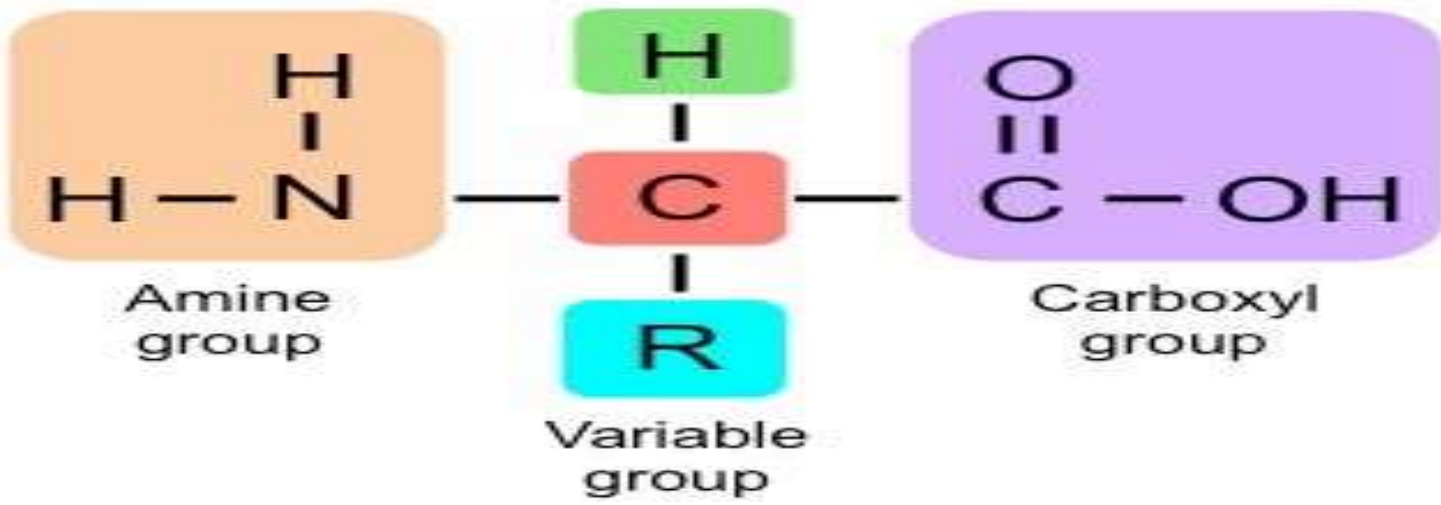
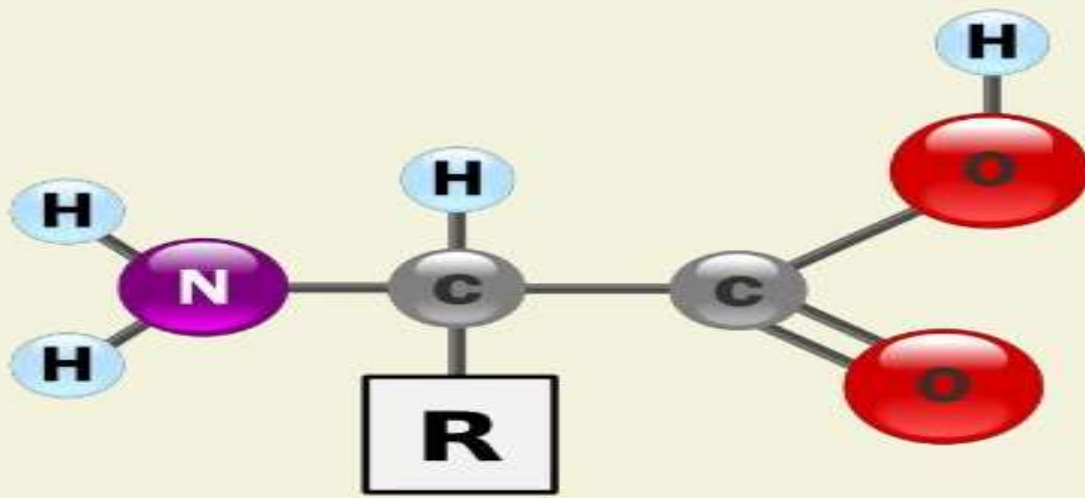
# Amino Acids

## Amino acids

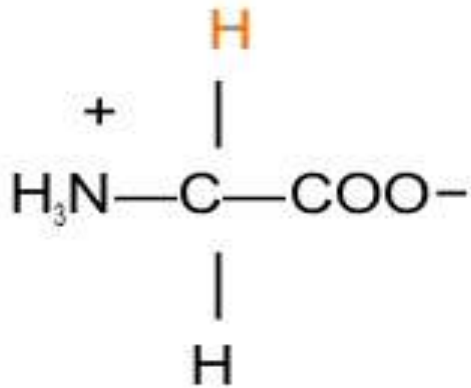
- Are the building blocks of proteins.
- There are 20 standard amino acids
- Contain a carboxylic acid group and an amino group on the alpha ( $\alpha$ ) carbon.
- Are ionized in solution.
- Each contain a different **side group (R)**.



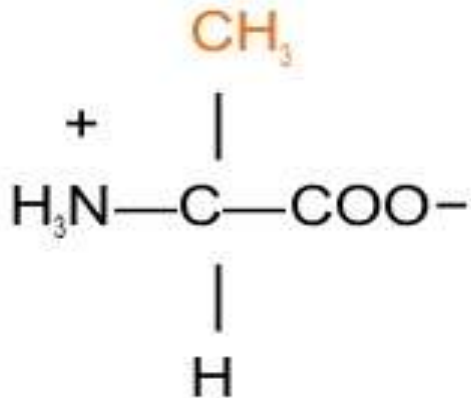
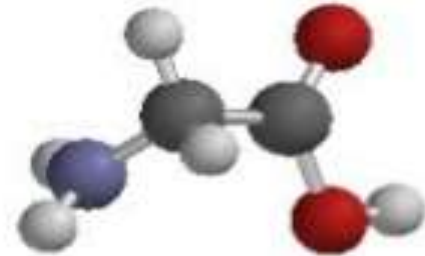
# BASIC STRUCTURE[SKELETON]



# Examples of Amino Acids



glycine



alanine



# NEED FOR CLASSIFICATION

- **Classification of amino acids gives the grouping between 20 acids and a basic outline for grouping.**
- **It makes a clear idea to pick the amino acid type**
- **This is much useful for biochemists for the easy understanding between each amino acids.**

## **CLASSIFICATION:**

- BASED ON NUMBER OF AMINO AND CARBOXYLIC GROUP
- BASED ON COMPOSITION OF SIDE CHAIN
- BASED ON THEIR STRUCTURE
- BASED ON POLARITY OF SIDE CHAIN OR R GROUP
- BASED ON ROLE IN PROTEIN FORMATION
- BASED ON ACID BASE PROPERTIES
- BASED ON NUTRITIONAL REQUIREMENT
- BASED ON METABOLIC FATE



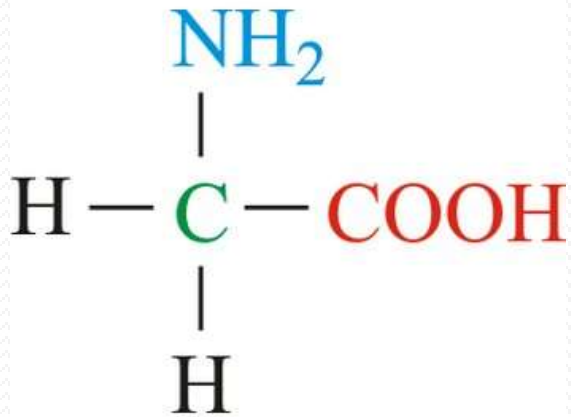
**BASED ON NUMBER OF AMINO AND CARBOXYLIC GROUP**

- 1. MONO AMINO MONO CARBOXYLIC ACID**
- 2. . MONO AMINO DICARBOXYLIC ACID**
- 3. DI AMINO MONO CARBOXYLIC ACID**

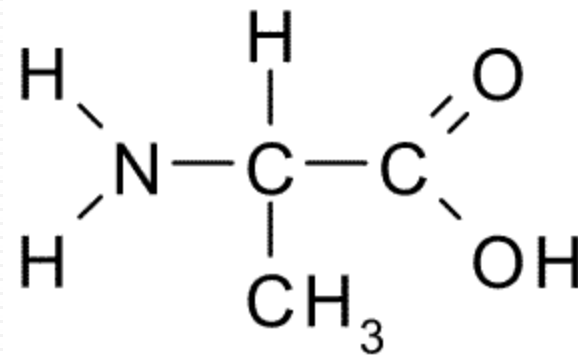


# I. BASED ON NUMBER OF AMINO AND CARBOXYLIC GROUP

1. MONO AMINO MONO CARBOXYLIC ACID- eg. GLYCINE, ALANINE

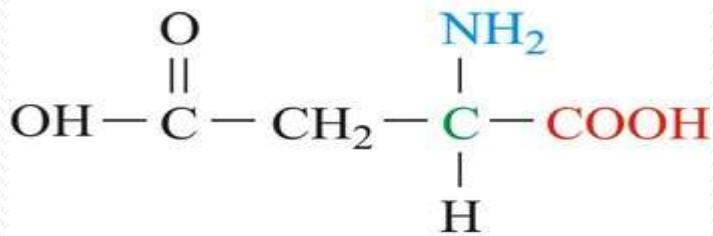


GLYCINE

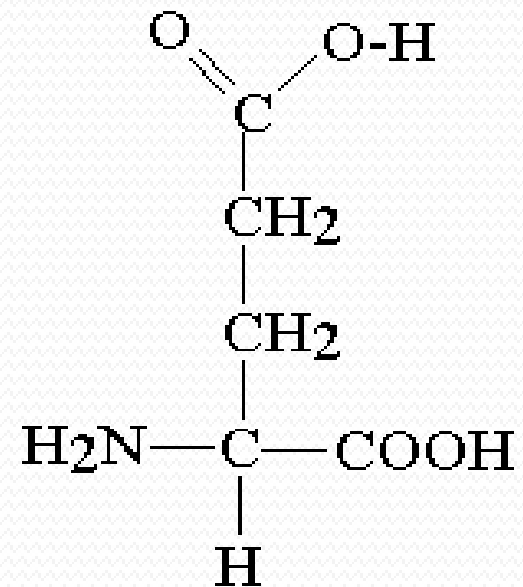


ALANINE

## 2. MONO AMINO DICARBOXYLIC ACID- ASPARTIC ACID, GLUTAMIC ACID



ASPARTIC ACID

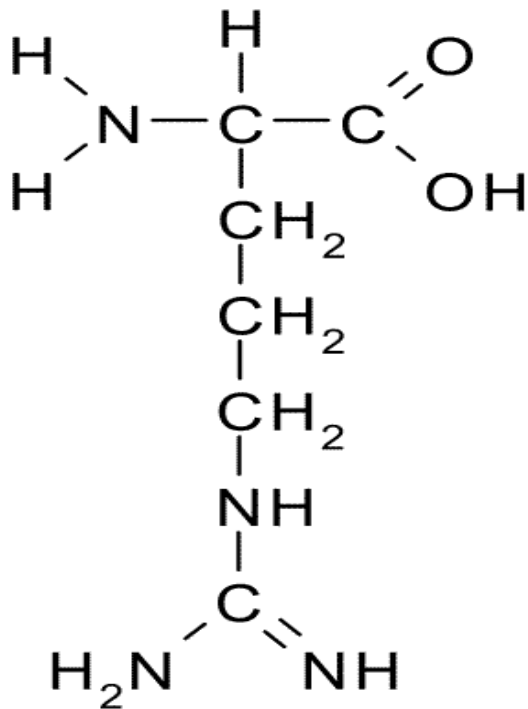


glutamic acid

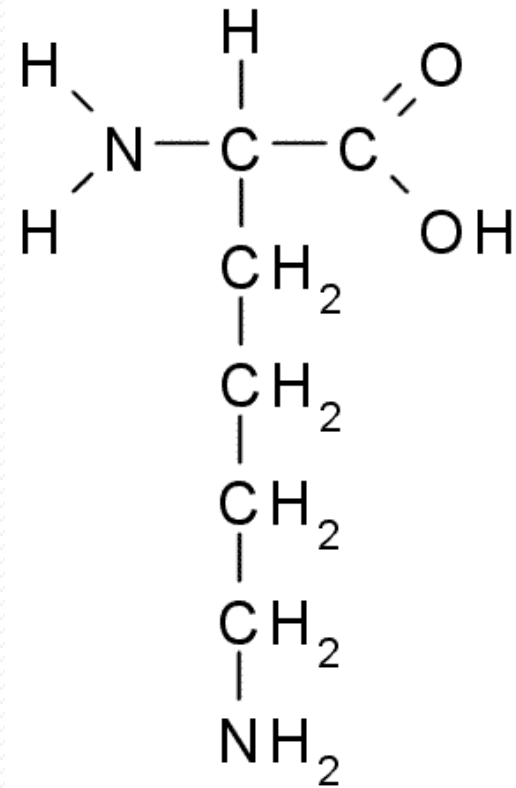
### 3. DI AMINO MONO CARBOXYLIC ACID

LYSINE, ARGININE, HISTIDINE

ARGININE



LYSINE

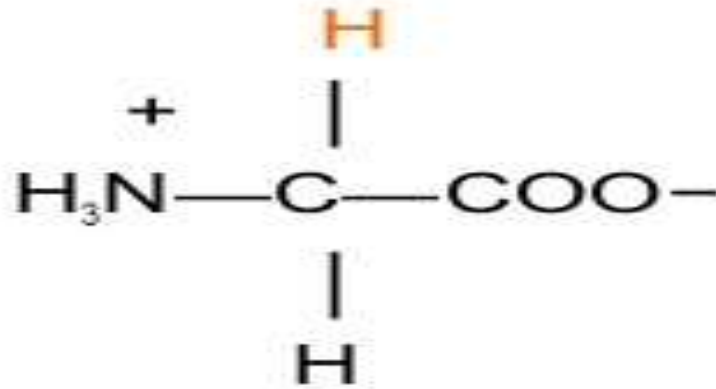


# **II. BASED ON THE SIDE CHAIN**

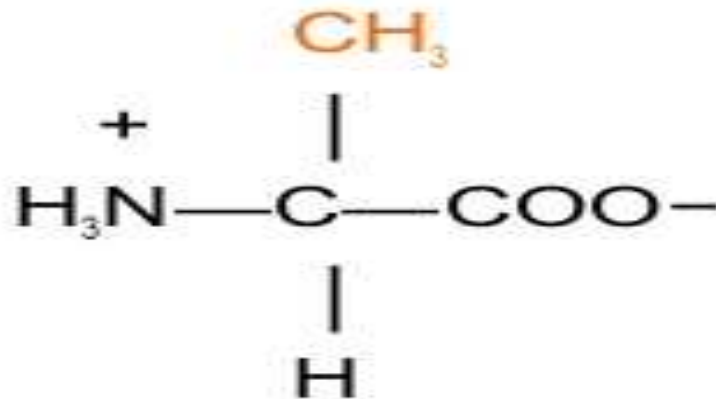
- 1. SIMPLE AMINO ACIDS**
- 2. HYDROXY AMINO ACIDS**
- 3. SULPHUR CONTAINING AMINO ACID**
- 4. ACIDIC AMINO ACIDS**
- 5. AMINO ACID AMIDES**
- 6. BASIC AMINO ACIDS**
- 7. AROMATIC AMINO ACIDS**
- 8. HETEROCYCLIC AMINO ACIDS-**

## II. BASED ON THE SIDE CHAIN

1. **SIMPLE AMINO ACIDS** :NO FUNCTIONAL GROUP IN THE SIDE CHAIN-*GLYCINE, VALINE, ALANINE*



glycine

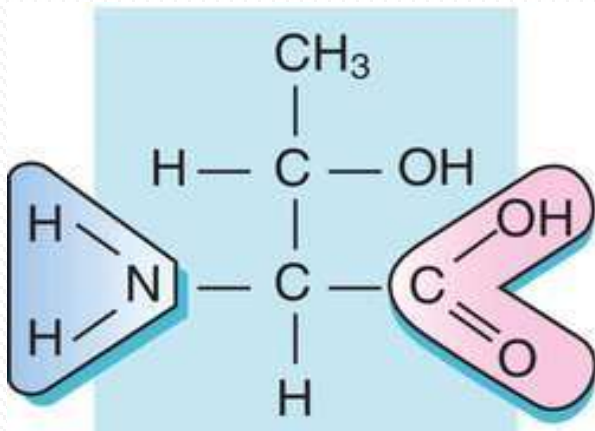


alanine

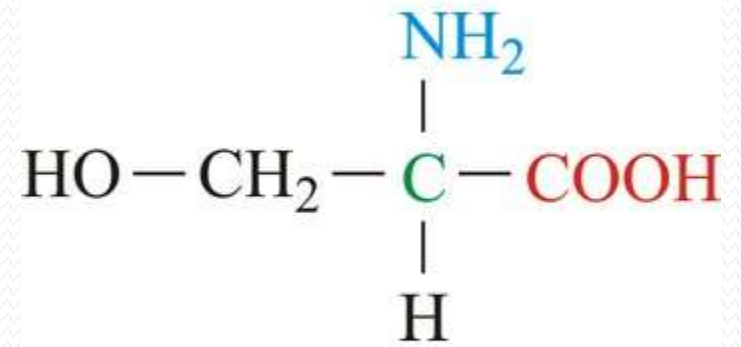
## 2. HYDROXY AMINO ACIDS: CONTAINS HYDROXYL GROUP IN THEIR SIDE CHAIN

*SERINE , THERONINE*

THREONINE



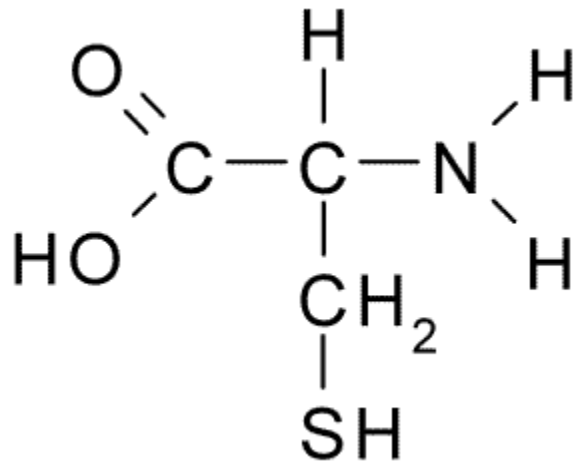
SERINE



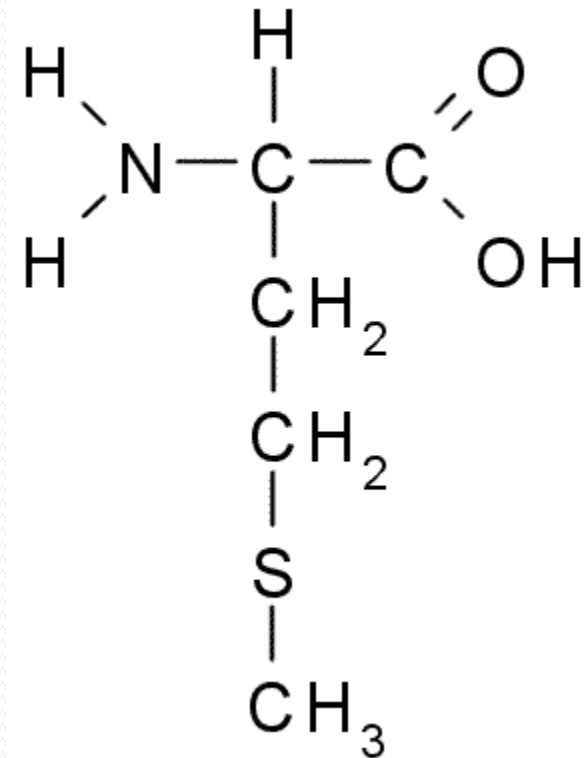
### 3. SULPHUR CONTAINING AMINO ACID: CONTAINS SULPHUR GROUP IN SIDE CHAIN

*CYSTEINE, METHIONINE*

CYSTEINE

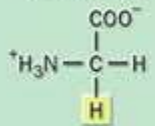


METHIONINE

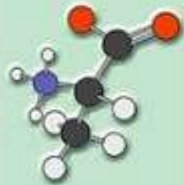
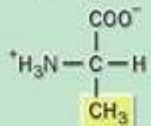


## Amino Acids With Aliphatic Side Chains

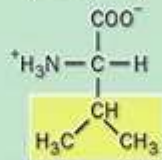
Glycine  
(Gly, G)



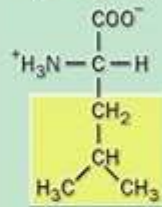
Alanine  
(Ala, A)



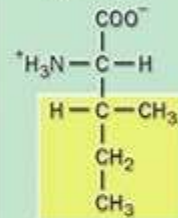
Valine  
(Val, V)



Leucine  
(Leu, L)



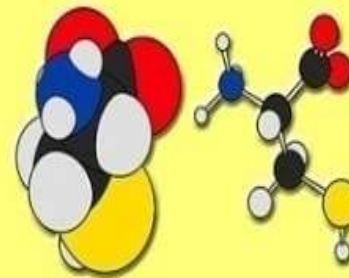
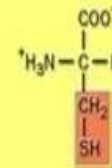
Isoleucine  
(Ile, I)



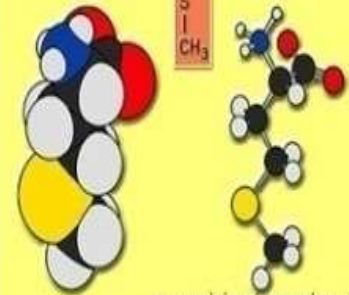
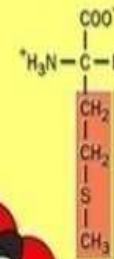
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## Amino Acids with Sulfur-containing Side Chains

Cysteine  
(Cys, C)



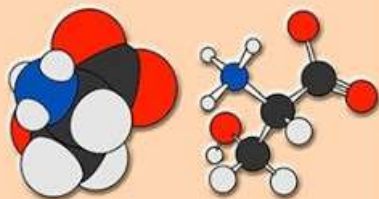
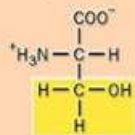
Methionine  
(Met, M)



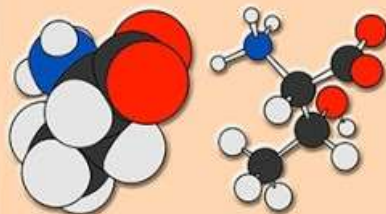
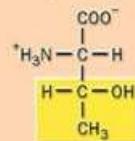
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## Amino Acids with Aliphatic Hydroxyl-containing Side Chains

Serine  
(Ser, S)



Threonine  
(Thr, T)



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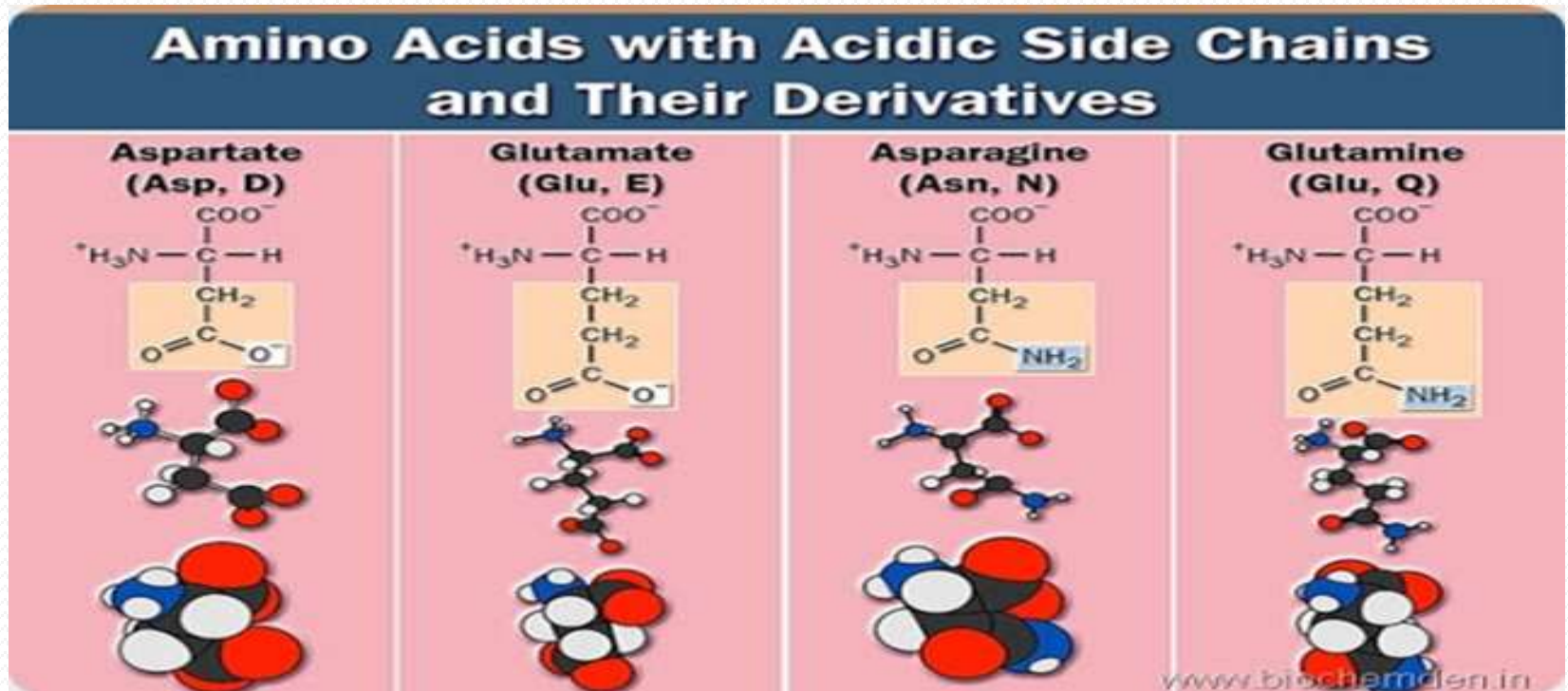
#### 4. ACIDIC AMINO ACIDS-

CONTAINS ADDITIONAL COOH GROUP

*ASPARTIC ACID, GLUTAMIC ACID*

#### 5. AMINO ACID AMIDES- ACIDIC AMINO ACIDS IN WHICH ONE OF COOH GROUP HAS BEEN TRANSFORMED TO AMIDE GROUP (CONH<sub>2</sub>)

*ASPARAGINE, GLUTAMINE*





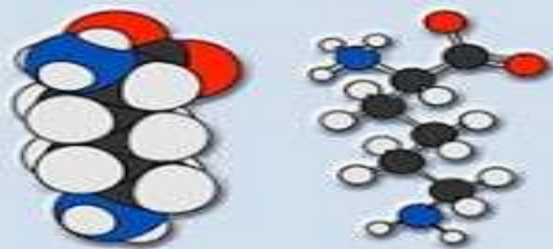
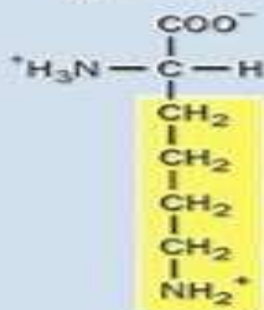
6. BASIC AMINO ACIDS- CONTAINS ADDITIONAL AMINO GROUP.  
LYSINE, ARGININE

7. AROMATIC AMINO ACIDS-CONTAINS BENZENE RING IN THE SIDE  
CHAIN. PHENYLALANINE, TYROSINE

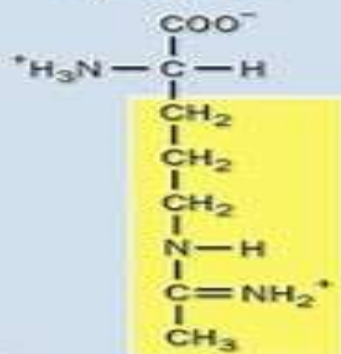
8. HETEROCYCLIC AMINO ACIDS-THEY POSSESS IN THEIR SIDE CHAIN A  
RING THAT CONTAIN AT LEAST ONE ATOM OTHER THAN THE CARBON.  
TRYPTOPHAN, HISTIDINE, PROLINE

# Amino Acids with Basic Side Chains

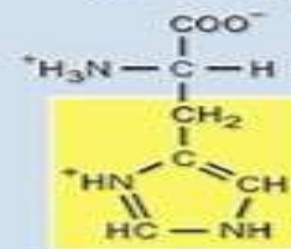
**Lysine**  
(Lys, K)



**Arginine**  
(Arg, R)

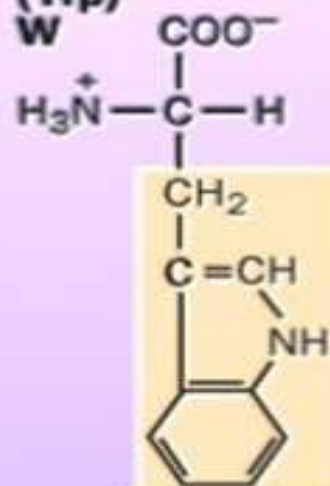


**Histidine**  
(His, H)



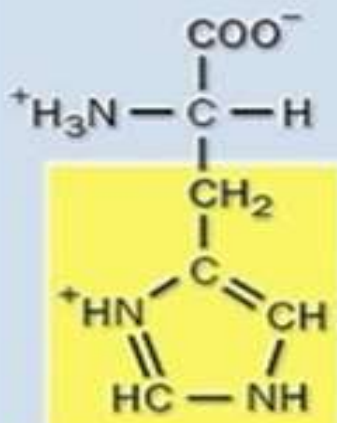
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**Tryptophan**  
(Trp)  
W



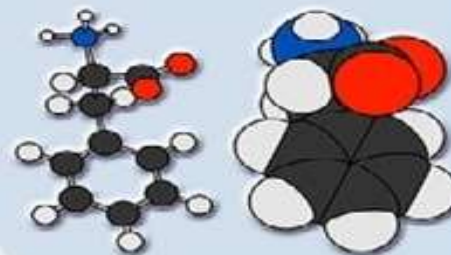
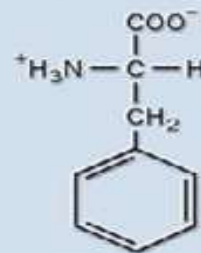
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**Histidine**  
(His, H)

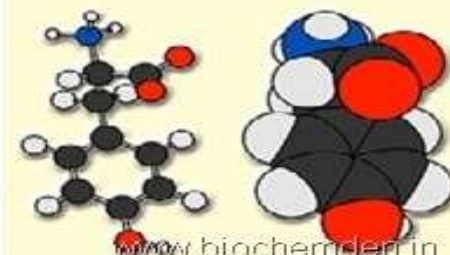
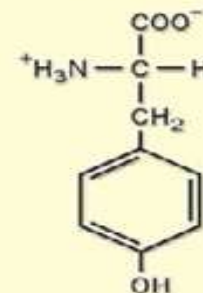


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**Phenylalanine**  
(Phe, F)



**Tyrosine**  
(Tyr, Y)



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### **III.ON THE BASIS OF THEIR STRUCTURE**

**1. ALIPHATIC AMINO ACIDS- *GLYCINE, CYSTEINE***

**2.AROMATIC AMINO ACIDS- *TYROSINE,PHENYL ALANINE***

**3.HETEROCYCLIC AMINO ACIDS- *TRYPTOPHAN***

## IV. ON THE BASIS OF POLARITY OF SIDE CHAIN

### B. CLASSIFICATION OF AMINO ACIDS BASED ON POLARITY

1. Non-polar amino acids with aliphatic 'R' group
2. Non-polar amino acids with aromatic 'R' group
3. Polar amino acids with no charge on 'R' group
4. Polar amino acids with negative 'R' group
5. Polar amino acid with positive 'R' group

## IV. ON THE BASIS OF POLARITY OF SIDE CHAIN

### 1. NON POLAR AMINO ACIDS WITH ALIPHATIC 'R' GROUP

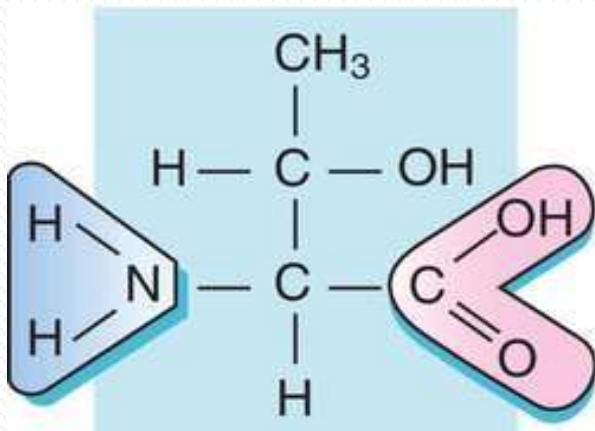
These amino acids are non polar and also referred to as hydrophobic (water hating). They have no charge on the 'R' group. The amino acids included in this group are Glycine, Alanine, Leucine, Isoleucine, Valine and Methionine

### 2. Non polar amino acids with aromatic 'r' group

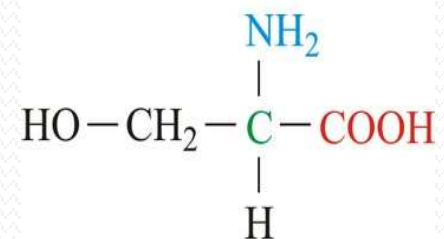
Their aromatic side chains are relatively nonpolar(hydrophobic). All can participate in hydrophobic interactions. The amino acids included in these groups are Phenylalanine, Tryptophan and tyrosine

**3. AMINO ACIDS WITH POLAR BUT UNCHARGED R Group**-side chain contains functional group in side chain. They are water soluble (hydrophilic). They possess neutral pH Value eg- *serine, threonine*

threonine



serine



4..**AMINO ACIDS WITH NEGATIVE CHARGE:**THEIR SIDE CHAIN CONTAIN EXTRA CARBOXYL GROUP,RESULTING IN NEGATIVE CHARGE.THESE ARE MONO AMINO DICARBOXYLIC ACIDS EG-*ASPARTIC ACID, GLUTAMIC ACID*

5.**AMINO ACID WITH POSITIVE CHARGE-** CONTAIN EXTRA AMINO GROUP. DIAMINO MONOCARBOXYL ACID EG-*LYSINE, ARGININE*



# Classification amino acids based upon polarity:1



| Sl<br>no. | Name | symbol    |          | Structure |
|-----------|------|-----------|----------|-----------|
|           |      | 3 letters | 1 letter |           |

1. AMINO ACIDS WITH ALIPHATIC SIDE CHAIN

|    |         |     |   |  |
|----|---------|-----|---|--|
| 1. | Glycine | Gly | G | $\boxed{\text{H}}-\text{CH}-\text{COO}^-$ $ $ $\text{NH}_3^+$  |
| 2. | Alanine | Ala | A | $\boxed{\text{CH}_3}-\text{CH}-\text{COO}^-$ $ $ $\text{NH}_3^+$   |
| 3. | Valine  | Val | V | $\begin{array}{c} \text{H}_3\text{C} \\ \diagdown \\ \text{CH} \\ \diagup \\ \text{H}_3\text{C} \end{array} -\text{CH}-\text{COO}^-$ $ $ $\text{NH}_3^+$ |

|    |            |     |   |   |
|----|------------|-----|---|---|
| 4. | Leucine    | Leu | L | $  \begin{array}{c}  \text{H}_3\text{C} \\  \diagdown \\  \text{CH}-\text{CH}_2 \\  \diagup \\  \text{H}_3\text{C}  \end{array}  \begin{array}{c}  -\text{CH}-\text{COO}^- \\    \\  \text{NH}_3^+  \end{array}  $            |
| 5. | Isoleucine | Ile | I | $  \begin{array}{c}  \text{CH}_3 \\  \diagdown \\  \text{CH}_2 \\  \diagdown \\  \text{CH} \\  \diagup \\  \text{H}_3\text{C}  \end{array}  \begin{array}{c}  -\text{CH}-\text{COO}^- \\    \\  \text{NH}_3^+  \end{array}  $ |

II. AMINO ACID CONTAINING HYDROXYL (-OH) GROUP

|    |           |     |   |   |
|----|-----------|-----|---|---|
| 6. | Serine    | Ser | S | $  \begin{array}{c}  \text{CH}_2 \\    \\  \text{OH}  \end{array}  \begin{array}{c}  -\text{CH}-\text{COO}^- \\    \\  \text{NH}_3^+  \end{array}  $                  |
| 7. | Threonine | Thr | T | $  \begin{array}{c}  \text{H}_3\text{C}-\text{CH} \\    \\  \text{OH}  \end{array}  \begin{array}{c}  -\text{CH}-\text{COO}^- \\    \\  \text{NH}_3^+  \end{array}  $ |

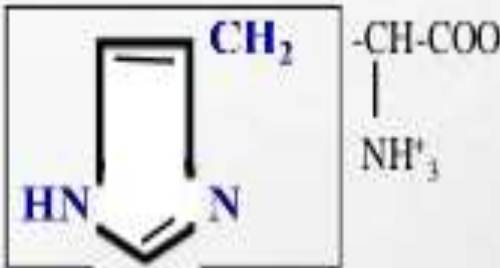
### III. SULFUR CONTAINING AMINO ACIDS

|    |            |     |   |  |
|----|------------|-----|---|--|
| 8. | Cysteine   | Cys | C | $\begin{array}{c} \boxed{\text{CH}_2} \\   \\ \text{SH} \end{array} \begin{array}{c} \text{-CH-COO} \\   \\ \text{NH}_3^+ \end{array}$                 |
| 9. | Methionine | Met | M | $\begin{array}{c} \boxed{\text{CH}_2\text{-CH}_2} \\   \\ \text{S-CH}_3 \end{array} \begin{array}{c} \text{-CH-COO} \\   \\ \text{NH}_3^+ \end{array}$ |

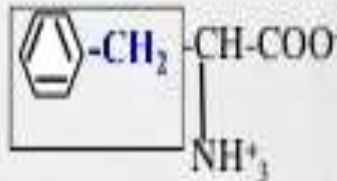
### IV. ACIDIC AMIO ACIDS AND THEIR AMIDES

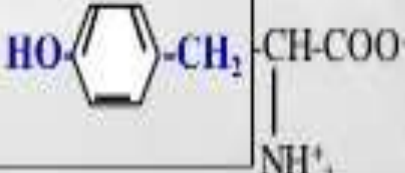
|     |               |     |   |  |
|-----|---------------|-----|---|--|
| 10. | Aspartic acid | Asp | D | $\begin{array}{c} \boxed{\text{-OOC-CH}_2} \\   \\ \text{-CH-COO} \\   \\ \text{NH}_3^+ \end{array}$   |
| 11. | Asparagine    | Asn | N | $\begin{array}{c} \boxed{\text{H}_2\text{N-C-CH}_2} \\    \\ \text{O} \end{array} \begin{array}{c} \text{-CH-COO} \\   \\ \text{NH}_3^+ \end{array}$ |

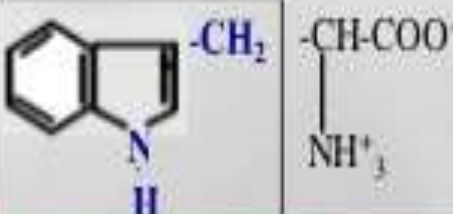
|                             |               |     |   |   |
|-----------------------------|---------------|-----|---|---|
| 12.                         | Glutamic acid | Glu | E | $\begin{array}{c} \boxed{\text{-OOC-CH}_2\text{-CH}_2\text{-}} \text{CH-COO}^- \\   \\ \text{NH}_3^+ \end{array}$   |
| 13.                         | Glutamine     | Gln | Q | $\begin{array}{c} \boxed{\text{H}_2\text{N-C-CH}_2\text{-CH}_2\text{-}} \text{CH-COO}^- \\    \\ \text{O} \\   \\ \text{NH}_3^+ \end{array}$                            |
| <i>v. Basic amino acids</i> |               |     |   |   |
| 14.                         | Lysine        | Lys | K | $\begin{array}{c} \boxed{\text{CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-}} \text{CH-COO}^- \\   \\ \text{NH}_3^+ \\   \\ \text{NH}_3^+ \end{array}$              |
| 15.                         | Arginine      | Arg | R | $\begin{array}{c} \boxed{\text{NH-CH}_2\text{-CH}_2\text{-CH}_2\text{-}} \text{CH-COO}^- \\   \\ \text{C=NH}_2^+ \\   \\ \text{NH}_2 \\   \\ \text{NH}_3^+ \end{array}$ |

|     |           |     |   |  |
|-----|-----------|-----|---|--|
| 16. | Histidine | His | H |  |
|-----|-----------|-----|---|--|

VI. AROMATIC AMINO ACIDS

|     |               |     |   |   |
|-----|---------------|-----|---|---|
| 17. | Phenylalanine | Phe | F |  |
|-----|---------------|-----|---|---|

|     |          |     |   |   |
|-----|----------|-----|---|---|
| 18. | Tyrosine | Tyr | Y |  |
|-----|----------|-----|---|---|

|     |            |     |   |  |
|-----|------------|-----|---|--|
| 19. | Tryptophan | Trp | W |  |
|-----|------------|-----|---|--|

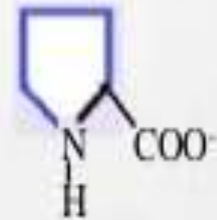
VI. Imino acid

20.

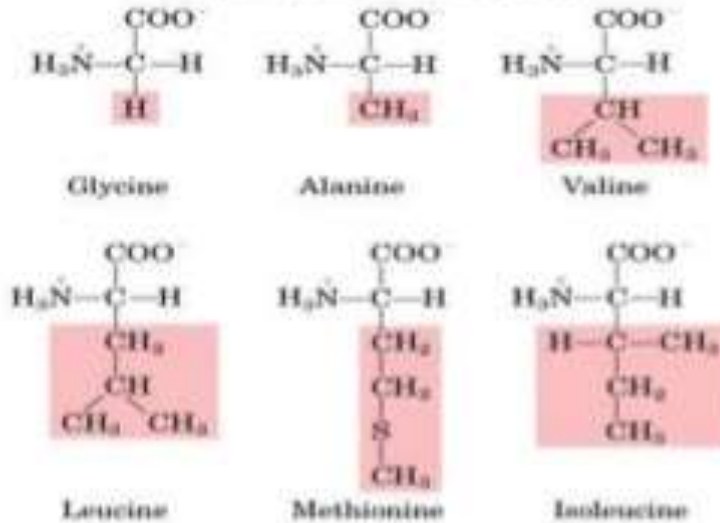
Proline

Pro

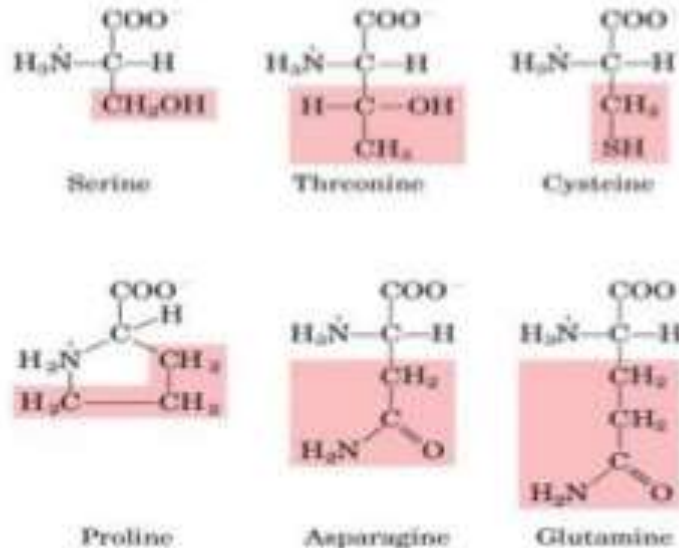
P



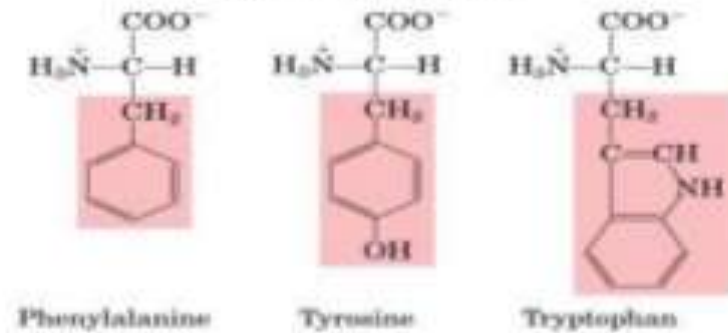
### Nonpolar, aliphatic R groups



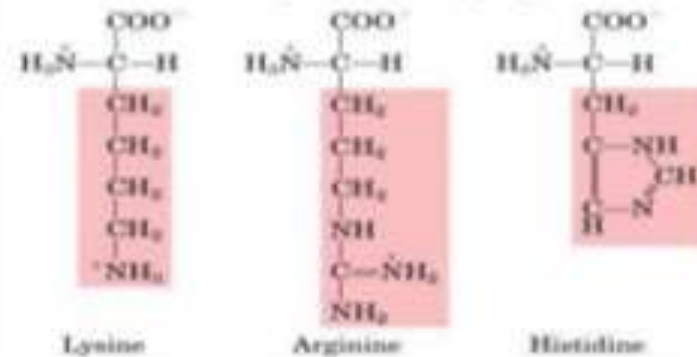
### Polar, uncharged R groups



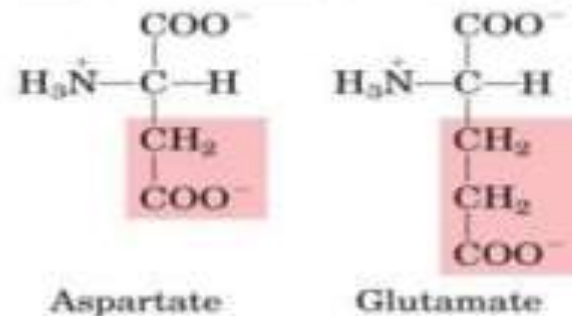
### Aromatic R groups



### Positively charged R groups

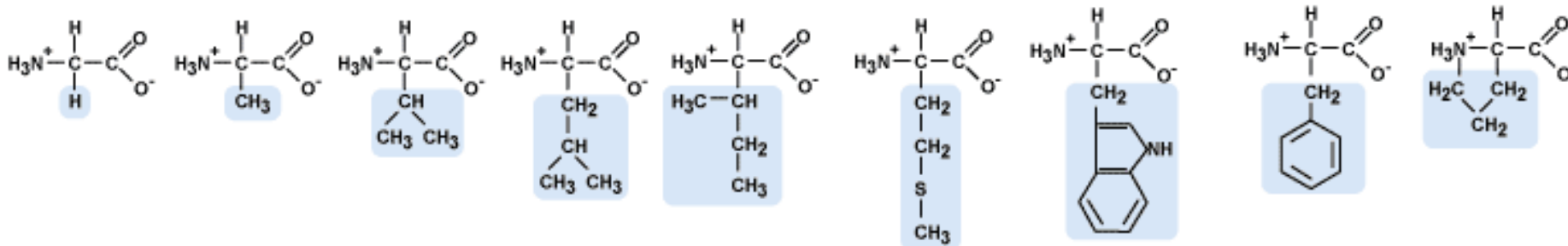


### Negatively charged R groups



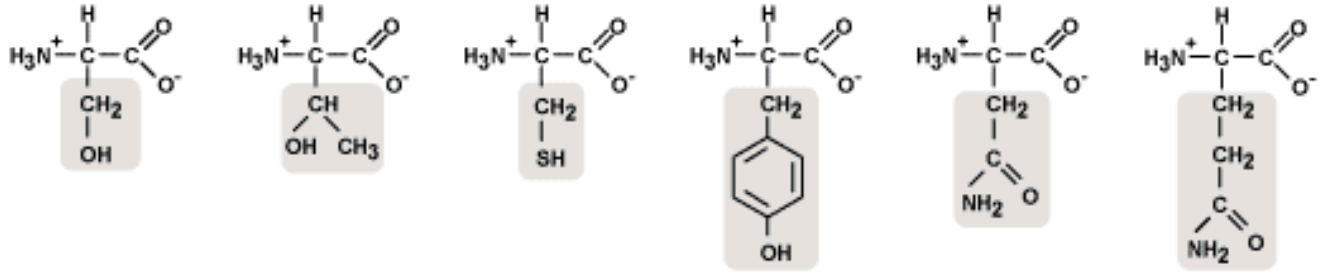


**NONPOLAR**



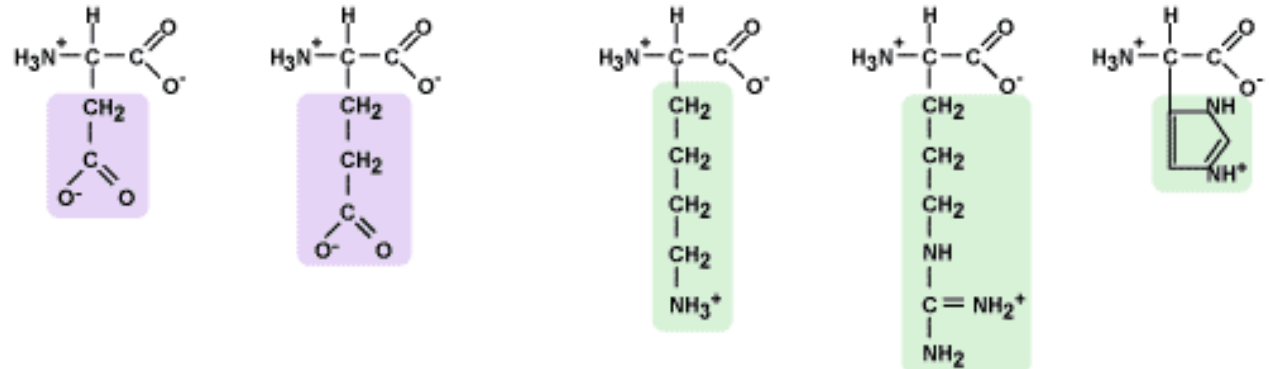
Glycine (Gly)    Alanine (Ala)    Valine (Val)    Leucine (Leu)    Isoleucine (Ile)    Methionine (Met)    Tryptophan (Trp)    Phenylalanine (Phe)    Proline (Pro)

**POLAR**



Serine (Ser)    Threonine (Thr)    Cysteine (Cys)    Tyrosine (Tyr)    Asparagine (Asn)    Glutamine (Gln)

**Electrically Charged**



**Acidic**

Aspartic Acid (Asp)    Glutamic Acid (Glu)

**Basic**

Lysine (Lys)    Arginine (Arg)    Histidine (His)

# **V. CLASSIFICATION OF AMINO ACIDS ON THE BASIS OF CATABOLISM**

**I. GLUCOGENIC AMINO ACIDS**

**II. KETOGENIC AMINO ACIDS**

**III. BOTH GLUCOGENIC AND KETOGENIC AMINO ACIDS:**

# V. CLASSIFICATION OF AMINO ACIDS ON THE BASIS OF CATABOLISM

## 1. GLUCOGENIC AMINO ACIDS:

These amino acids serve as precursors gluconeogenesis for glucose formation. These are amino acids whose catabolic products enter into glucose formation

GAMD (*GLYCINE, ALANINE, METHIONINE, ASPARTIC ACID*).

## 2. KETOGENIC AMINO ACIDS:

These are amino acids whose catabolic products enter the pathway of lipid metabolism and form ketone bodies.

*Leucine and lysine*

### **3. BOTH GLUCOGENIC AND KETOGENIC AMINO ACIDS:**

These amino acids breakdown to form precursors for both ketone bodies and glucose. They may either enter glucogenic pathway or metabolic pathway of lipids

***ISOLEUCINE, PHENYLALANINE, TRYPTOPHAN AND TYROSINE***

## Based on nutritional requirements:

- Essential amino acids:

**Essential amino acids** cannot be made by the body.

As a result, they must come from food.

The **essential amino acids** are: Arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

# Essential Amino Acids

Arginine

Threonine

Valine

Leucine

Histidine

**M A T T V I L P H Ly**

Methionine

Tryptophan

Isoleucine

Phenyl Alanine

Lysine

[www.BiochemDen.com](http://www.BiochemDen.com)

- Non essential amino acids:

An **amino acid** that can be made by humans and so is essential to the human diet.

The **nonessential amino acids**: Alanine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, and tyrosine.

## NON ESSENTIAL



Alanine  
Arginine  
Asparagine  
Aspartate  
Cystine  
Glutamic  
Glycine  
Ornithine  
Proline  
Serine  
Tyrosine

## ESSENTIAL



Histidine  
Isoleucine  
Leucine  
Lysine  
Methionine  
Phenylalanine  
Threonine  
Tryptophan  
Valine



# **BASED ON ROLE IN PROTEIN FORMATION**

## **1. PROTEOGENIC AMINO ACIDS**

### **a. MAJOR PROTEOGENIC AMINO ACIDS**

### **b. RARE PROTEOGENIC AMINO ACIDS**

## **2. NON PROTEOGENIC AMINO ACIDS :**

# BASED ON ROLE IN PROTEIN FORMATION

1. **PROTEOGENIC AMINO ACIDS**: Proteogenic amino acids enter into the formation of proteins. They are again of two types

a. **MAJOR PROTEOGENIC AMINO ACIDS**: They are primary constituents of all natural proteins. They are 20 in number. They are generally called as **STANDARD , NORMAL OR PRIMARY AMINO ACIDS**. ALSO CALLED “**MAGIC 20**”. EG- LYSINE, ALANINE etc

b. **RARE PROTEOGENIC AMINO ACIDS**: They are also called **non standard** . they are derivatives of primary ones. Eg- hydroxy proline( it is a derivative of proline) found in collagen



**2. NON PROTEOGENIC AMINO ACIDS:** These are not usually incorporated with proteins, they occur as metabolites either in free or non protein state

eg- histamine

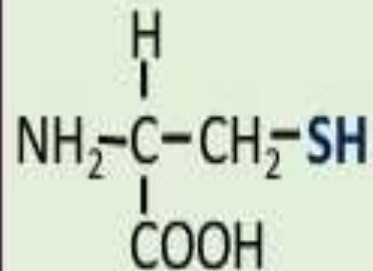
# Selenocysteine: 21<sup>st</sup> amino acid

## ❖ Selenocysteine:

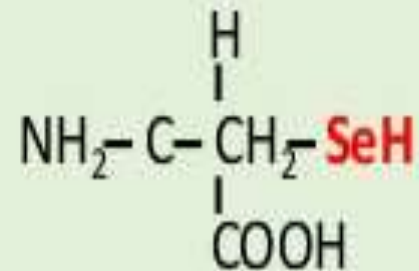
- 21<sup>st</sup> amino acid present in human body Protein (incorporated in 25 proteins)
- Instead of **SH**(sulfhydryl)group in **Cysteine**, **SeH** (**Selenium**) is present in **Selenocysteine**
- **Nomenclature** by IUPA / IUBMB : three letter Abbreviation as **SeCys** or **SeC** and one letter symbol as **U** for selenocysteine
- have **separate codon UGA** that normally functions as **stop codon/signal**.
- has specialized **eukaryotic t-RNA i.e. t-RNA Sec** : with different primary and secondary structure (a long variable region arm, 9 base pairs in acceptor stem, substitution at several well conserved base positions )
- Incorporated as such into proteins during protein biosynthesis and proteins containing selenocysteine are called as **Selenoproteins** .

# Structure of Selenocysteine

## Cysteine



## Selenocysteine



❖ **Selenocysteine** : has a structure similar to Cysteine ,but with Selenium atom taking place of the usual sulfur.

# **BASED ON ACID BASE PROPERTIES**

**1. ACIDIC AMINO ACIDS- CONTAINS ADDITIONAL COOH GROUP. THEY ARE POLAR, HYDROPHILIC**

**EG GLUTAMIC ACID**

**2. BASIC AMINO ACIDS- ADDITIONAL AMINO GROUP IS PRESENT. ARE POLAR, HYDROPHILIC**

**EG LYSINE, ARGININE**

**3. NEUTRAL AMINO ACIDS- HAVE NEITHER ACIDIC NOR BASIC GROUP IN THEIR SIDE CHAIN**



**THANK YOU**