By.
S.K.Sinha

Chapter

Amino-Acids & Proteins

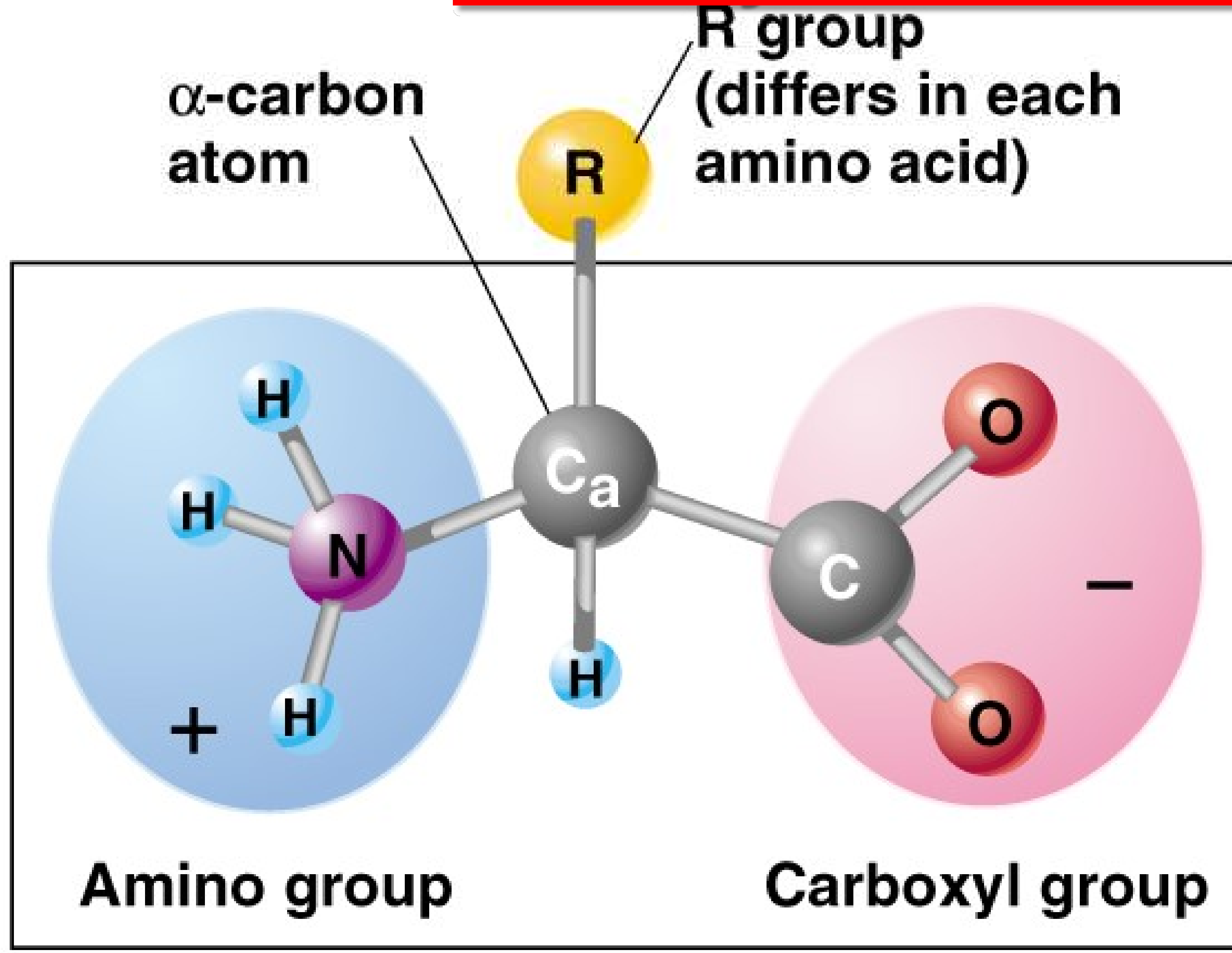
(Session -3)

By
S.K.Sinha

Topics Covered in this Lecture

1	**Amino acids and Proteins**
2	**Classification of Amino Acids**
3	**Zwitter Ion and Isoelectric point**
4	**Peptide linkage and Sequencing**
5	**Structure of Proteins**

Anatomy of an amino acid



Structures common to all amino acids

Amino Acids

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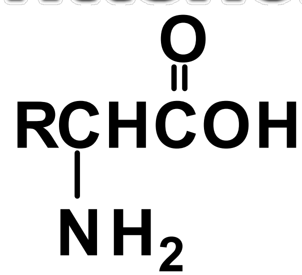
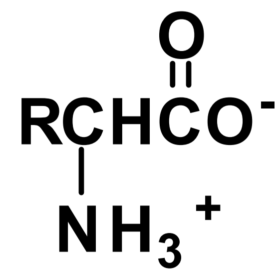
Amino acid: A compound that contains both an amino group and a carboxyl group.

α-Amino acid: An amino acid in which the amino group is on the carbon adjacent to the carboxyl group.

although α-amino acids are commonly written in the unionized form, they are **more properly written** in the **zwitterion** (internal salt) form.



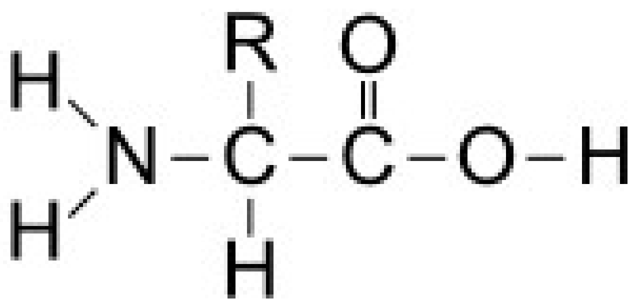
α-Amino Acid



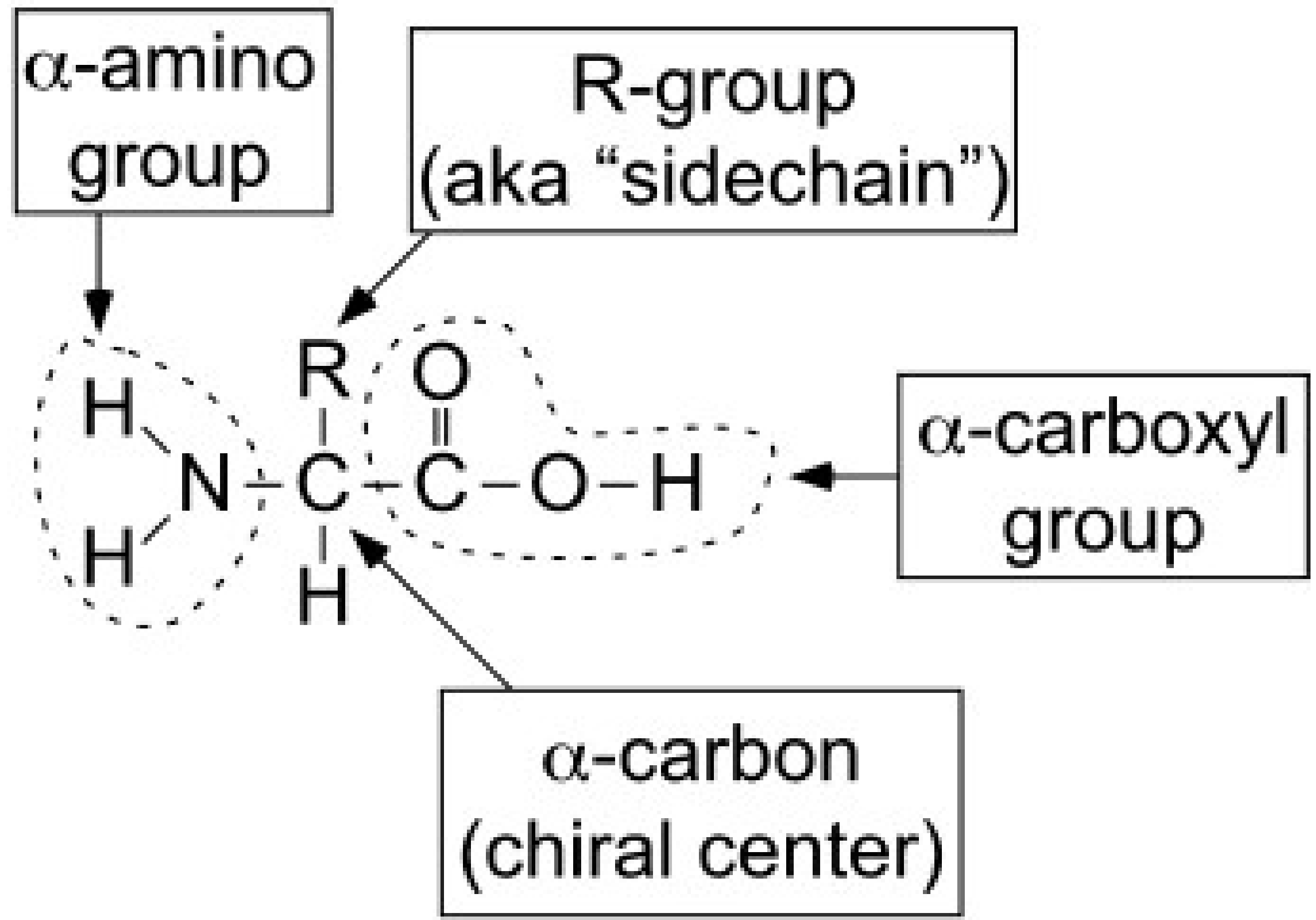
Zwitterion form

Anatomy of an amino acid

General amino acid structure



Chemical anatomy of an amino acid



Anatomy of an amino acid

20 different amino acids occur in living cells.

4 chemical groups (composition of the R group):

- **Acidic (negatively charged), (*n* = 2)**
- **Basic (positively charged), (*n* = 3)**
- **Neutral and polar, hydrophilic, (*n* = 6)**
- **Neutral and non-polar, hydrophobic, (*n* = 9)**

No. of Carbon

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Glutamic	2	(Carboxylic)
Glutamine	2	(Carboamide)
Lysine	4	(Amine)
Arginine	3	(Gua)
Threonine	2	(OH)
Methionine	2	(SMe)
Glycine	0	
All other	1.	

Glycine

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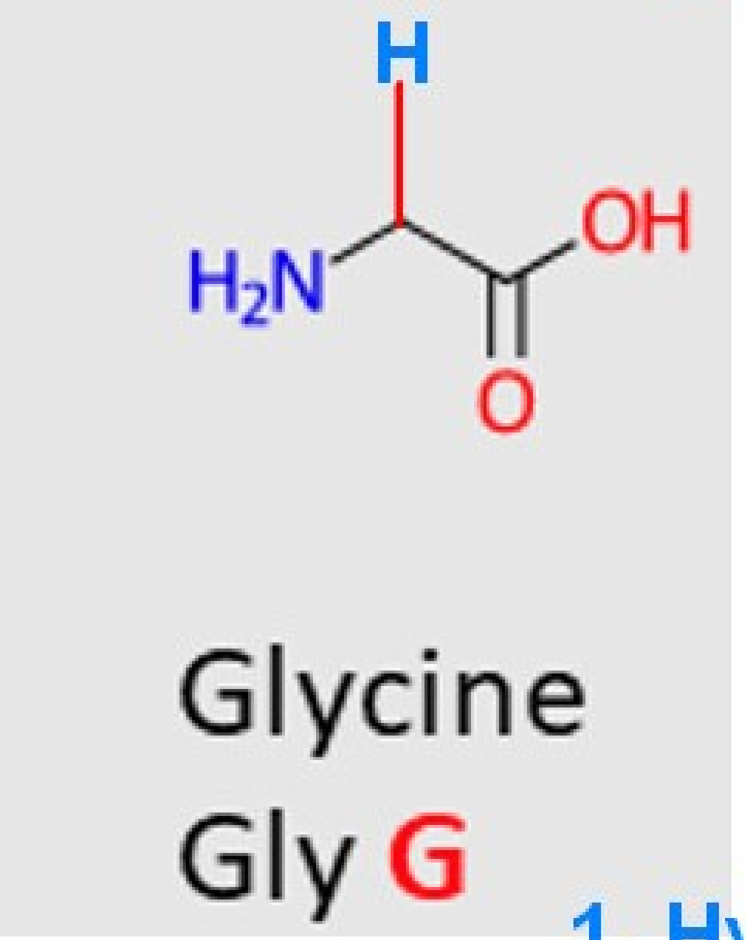
Acyclic HC.



1. Hydrogen

Alanine

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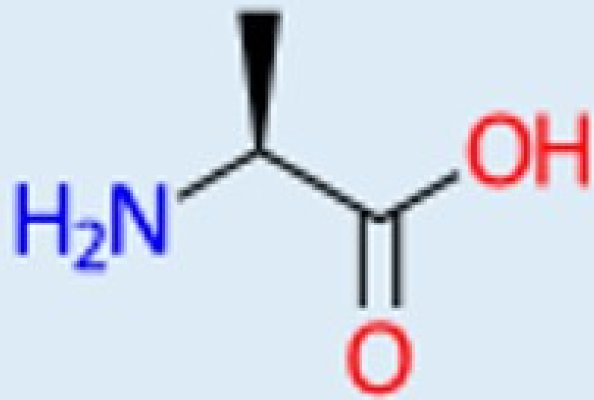
Acyclic HC.



Alanine

Ala **A**

1. Methyl

Valine

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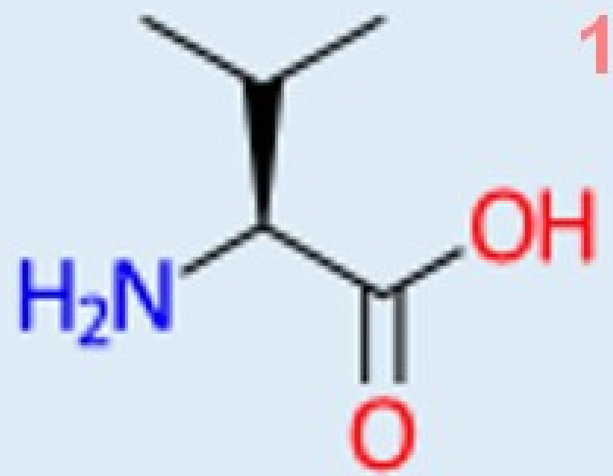

1. Acyclic HC.

Valine

Val V

1. Isopropyl

Leucine

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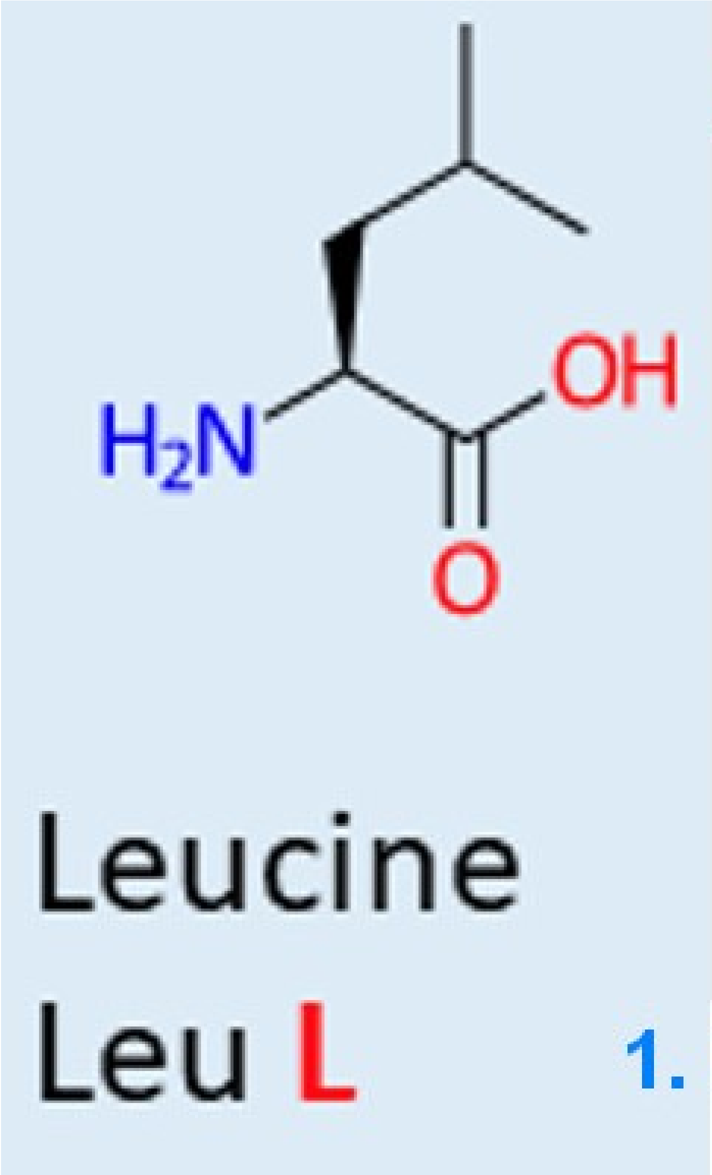

Acyclic HC

1. Isobutyl

Iso-leucine

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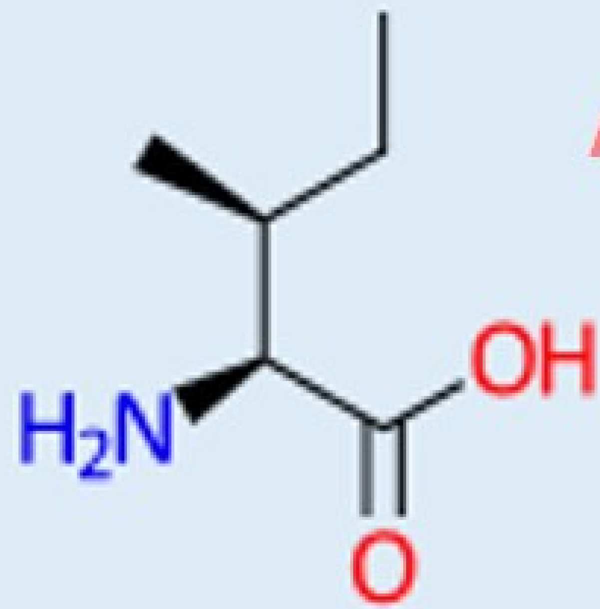
Acyclic HC.



Isoleucine

Ile I

1. Sec - Butyl

Proline

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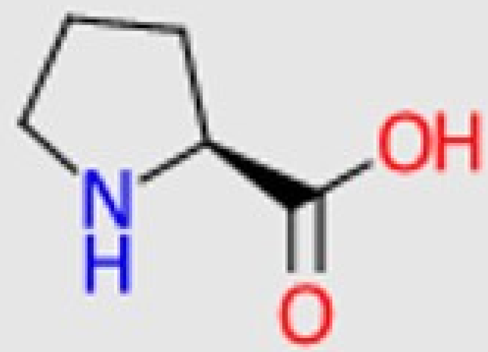

Cyclic HC.

Proline

Pro **P**

1. Propyl in ring

PhenylAlanine

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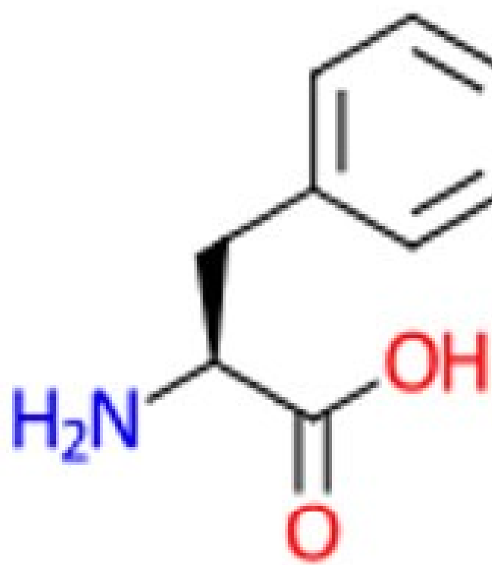
Aromatic



Phenylalanine

Phe **F**

1. Methyl
2. Benzene

Tyrosine

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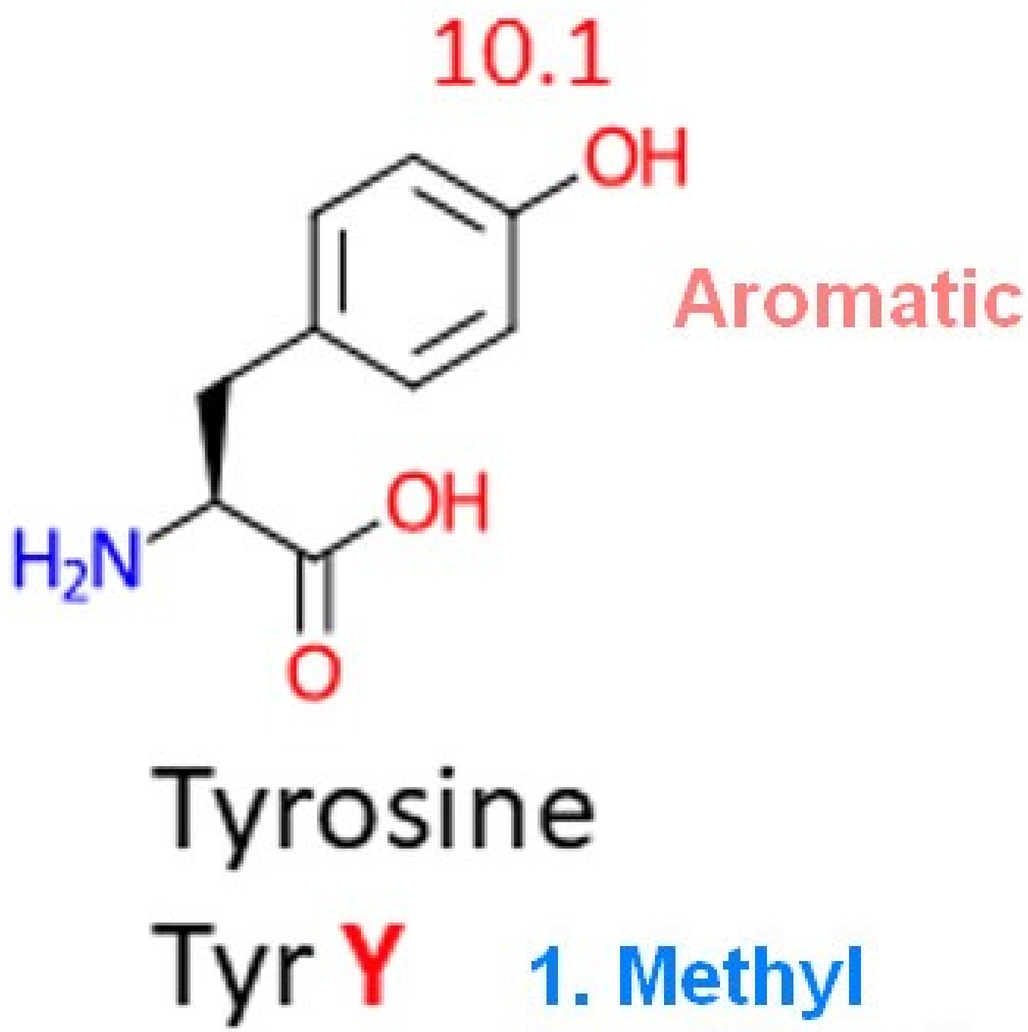

1. Methyl
2. p-Phenol

Tryptophan

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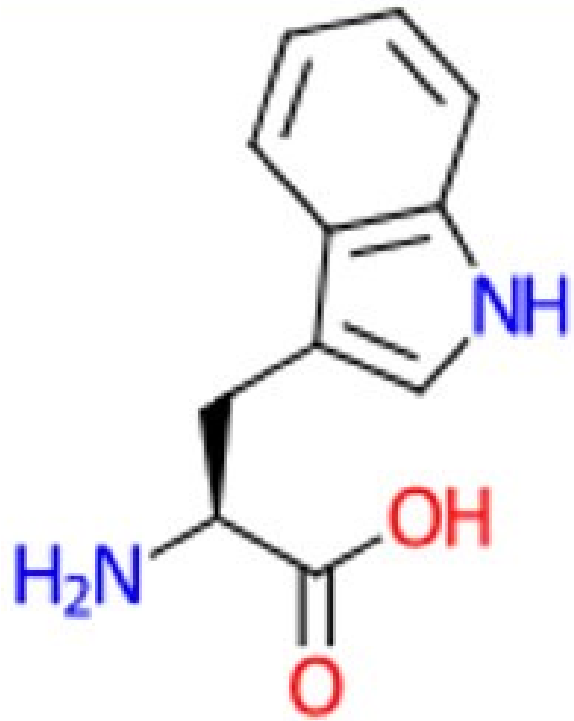

Aromatic

Tryptophan

Trp W

1. Methyl
2. 3-Indole

Serine

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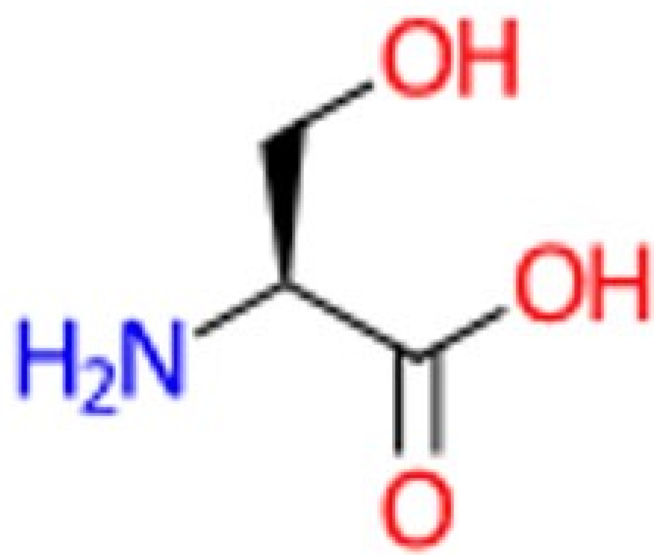

Serine

Ser **S**

1. Methyl
2. Hydroxy

Threonine

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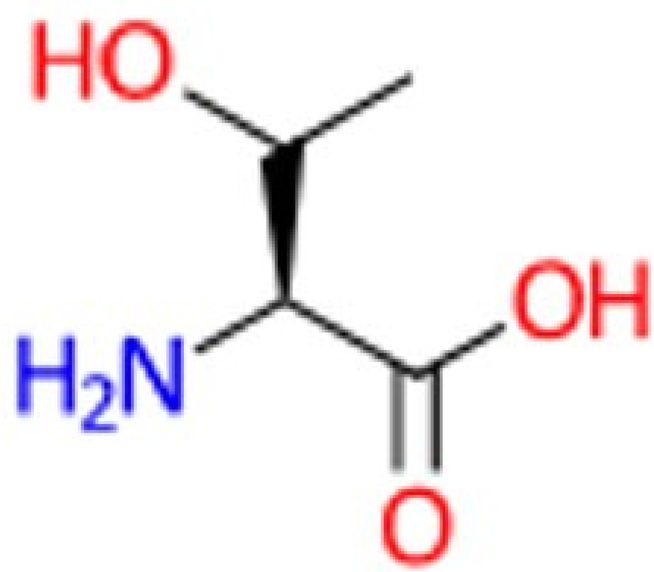

Threonine

Thr T

1. Ethyl
2. 1-Hydroxy

Cysteine

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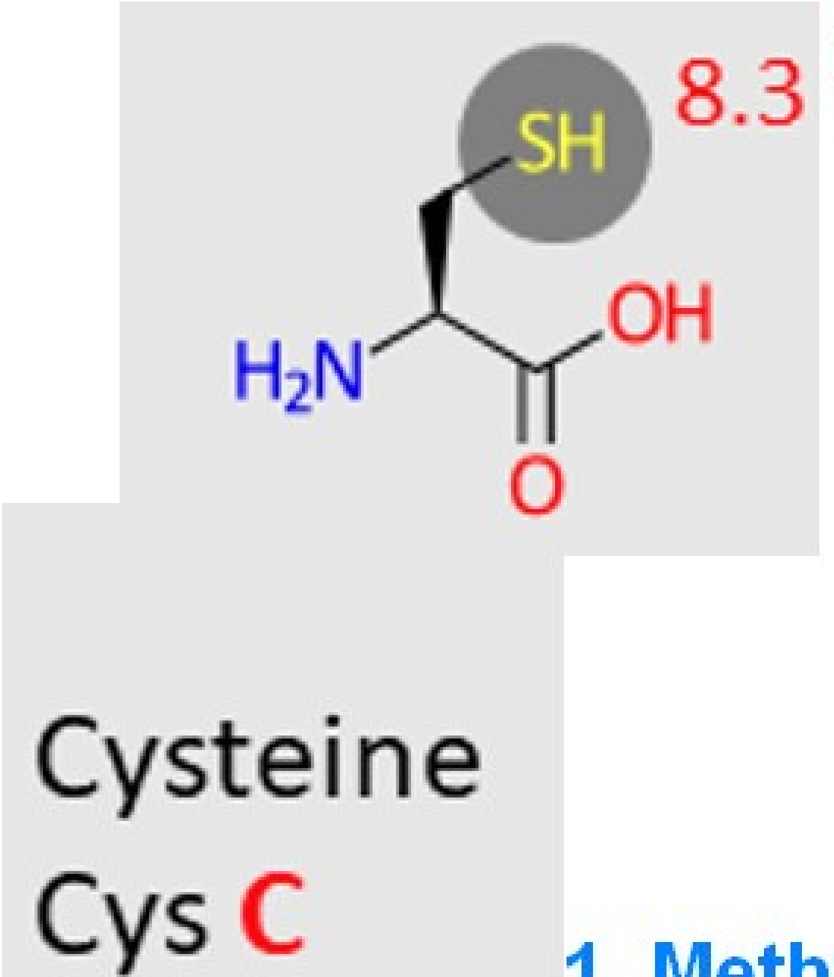

8.3 Sulphur

1. Methyl
2. Thiol

Methionine

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Sulphur

1. Ethyl
2. Methylthio

Aspartic acid

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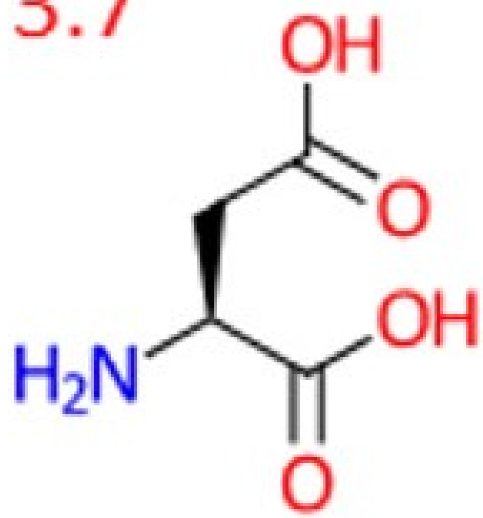
3.7



Acidic

Aspartic Acid

Asp **D**

1. Methyl
2. Carboxylic acid

Glutamic acid

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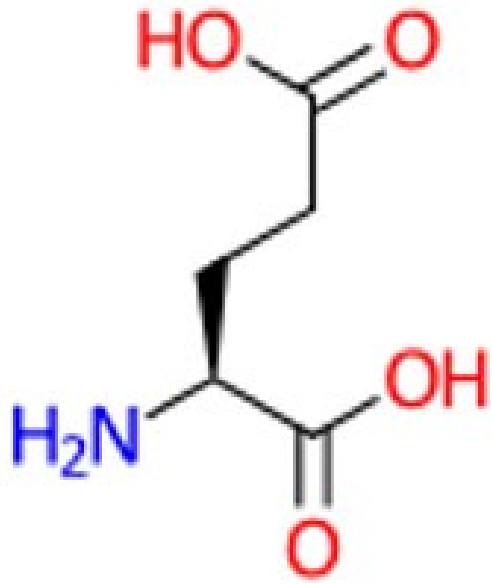

4.2 Acidic

Glutamic Acid

Glu **E**

1. Ethyl
2. Carboxylic Acid

Asparagine

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1.Methyl
2. Carboxamide

Asparagine

Asn N

Glutamine

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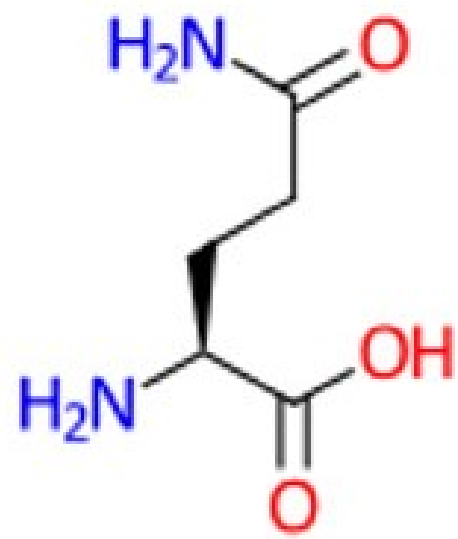

Glutamine

Gln **Q**

1. Ethyl
2. Carboxamide

Lysine

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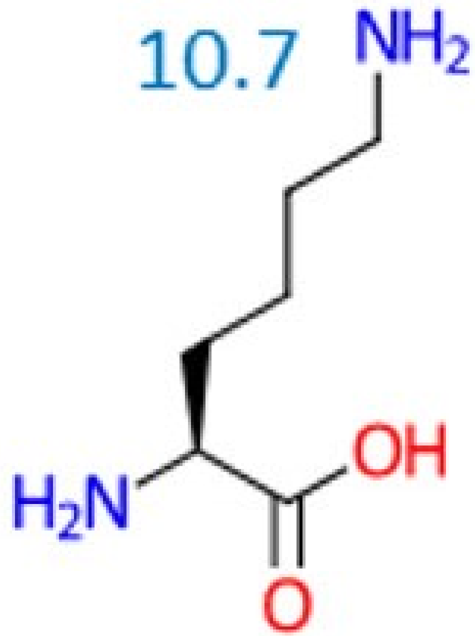

Basic

Lysine

Lys **K**

1. **Butyl**
2. **Amine**

Arginine

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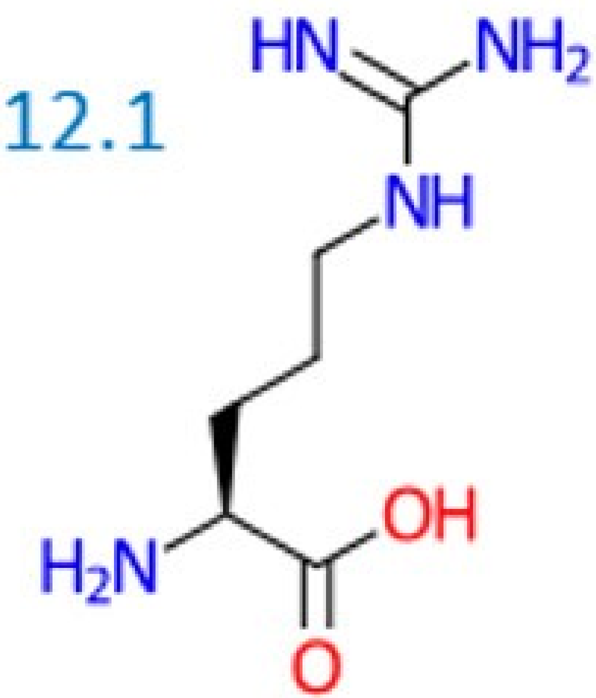
12.1



Arginine

Arg **R**

1. Propyl

2. Guanadine

Histidine

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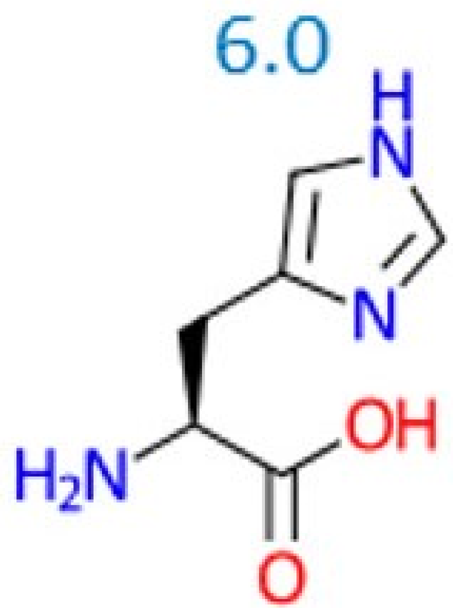

Basic

Histidine

His **H**

1. **Methyl**
2. **Imidazole**

No. of Carbon

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Glutamic	2	(Carboxylic)
Glutamine	2	(Carboamide)
Lysine	4	(Amine)
Arginine	3	(Gua)
Threonine	2	(OH)
Methionine	2	(SMe)
Glycine	0	
All other	1.	

The 20 Amino Acids

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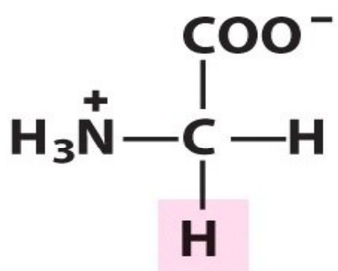
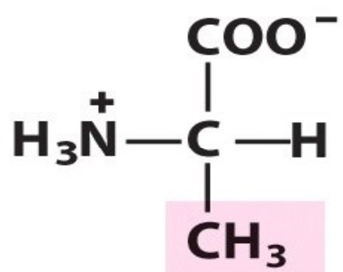
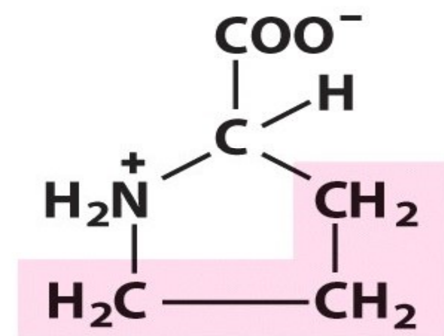
Nonpolar, aliphatic R groups



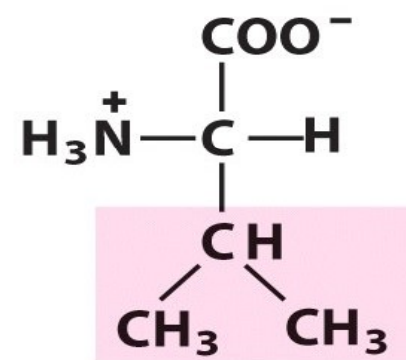
Glycine



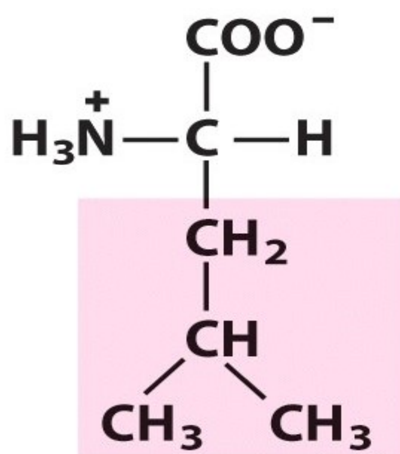
Alanine



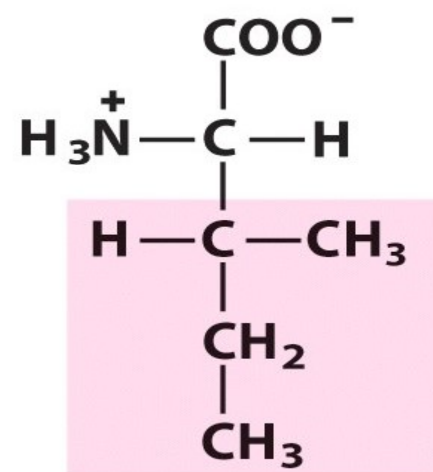
Proline



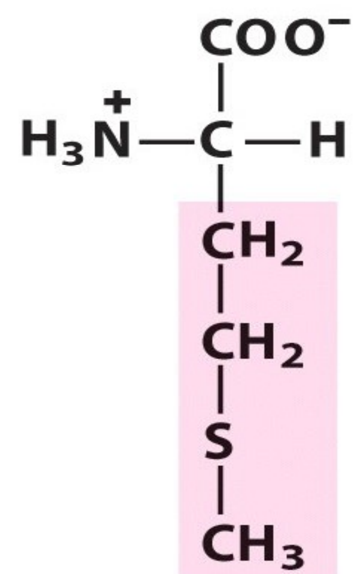
Valine



Leucine



Isoleucine



Methionine

The 20 Amino Acids

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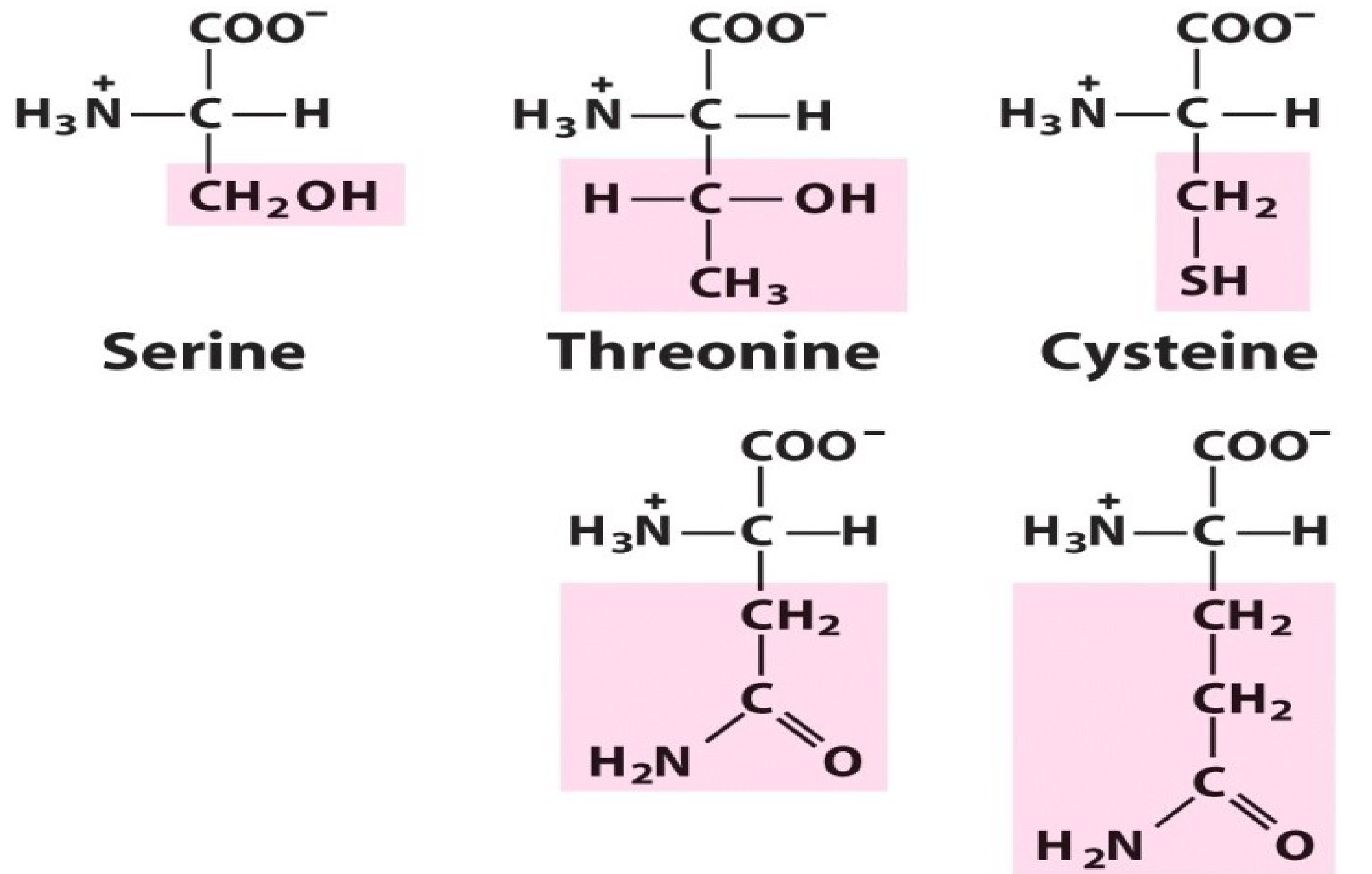
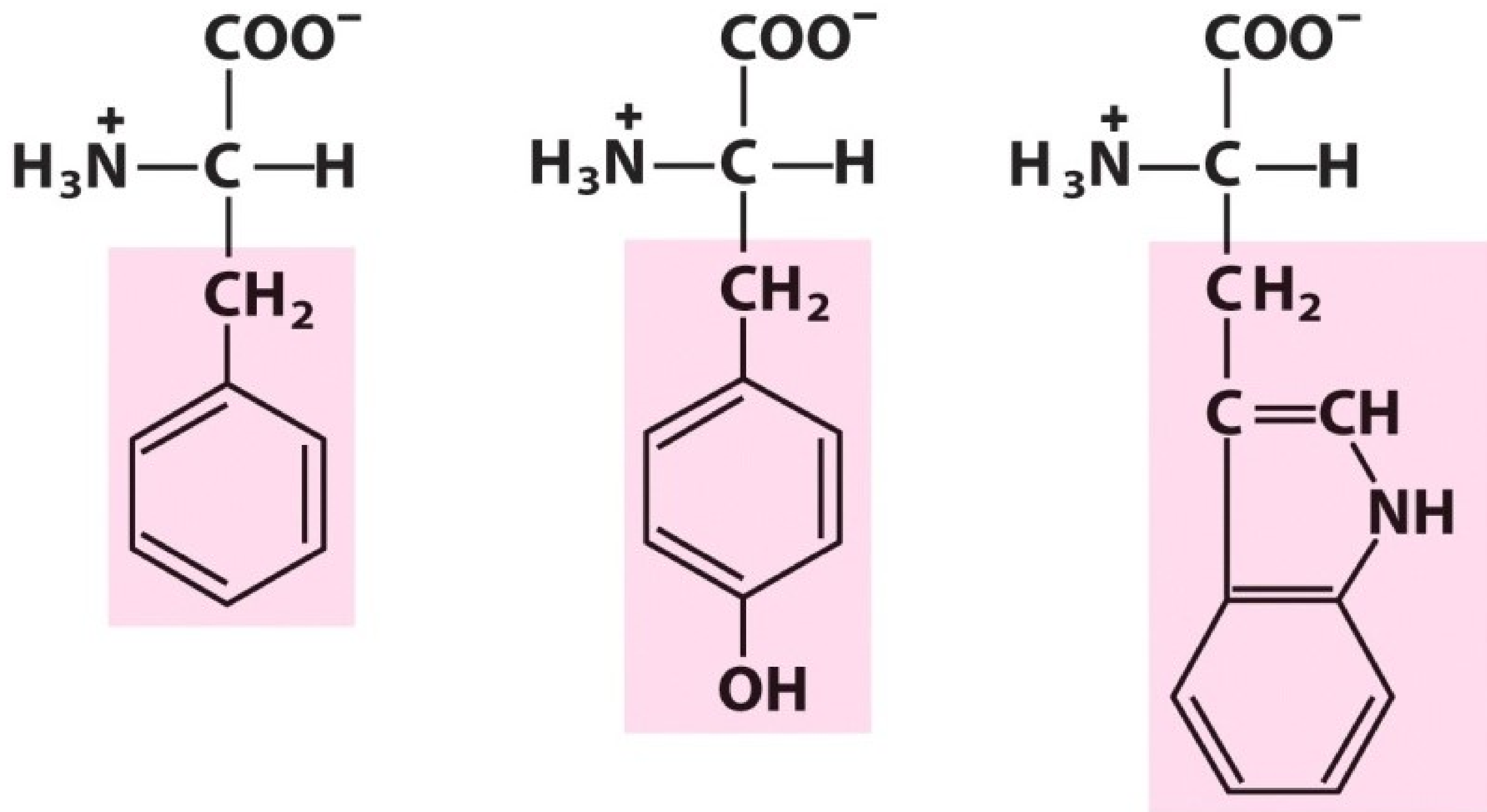
Polar, uncharged R groups



Serine, Threonine, Cysteine, Asparagine, Glutamine

The 20 Amino Acids

Aromatic R groups



Phenylalanine Tyrosine Tryptophan

The 20 Amino Acids

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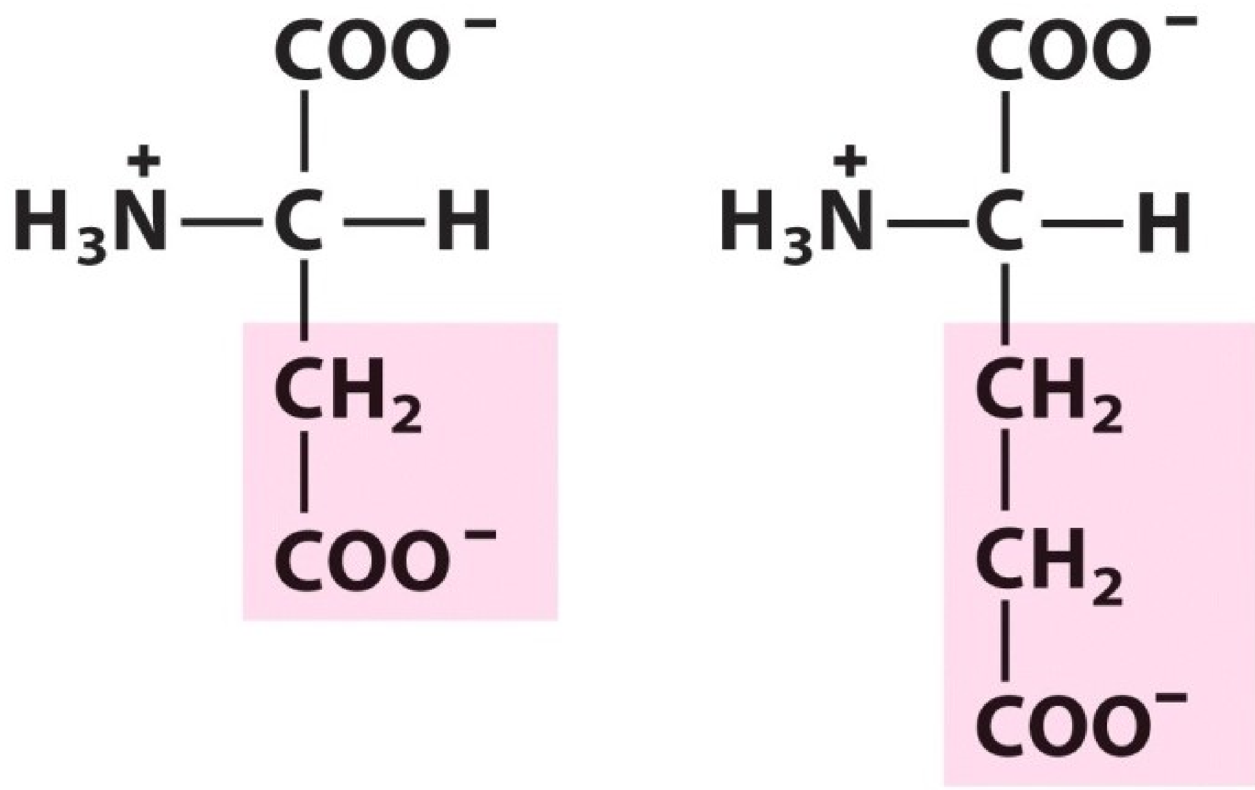
Negatively charged R groups



Aspartate Glutamate

The 20 Amino Acids

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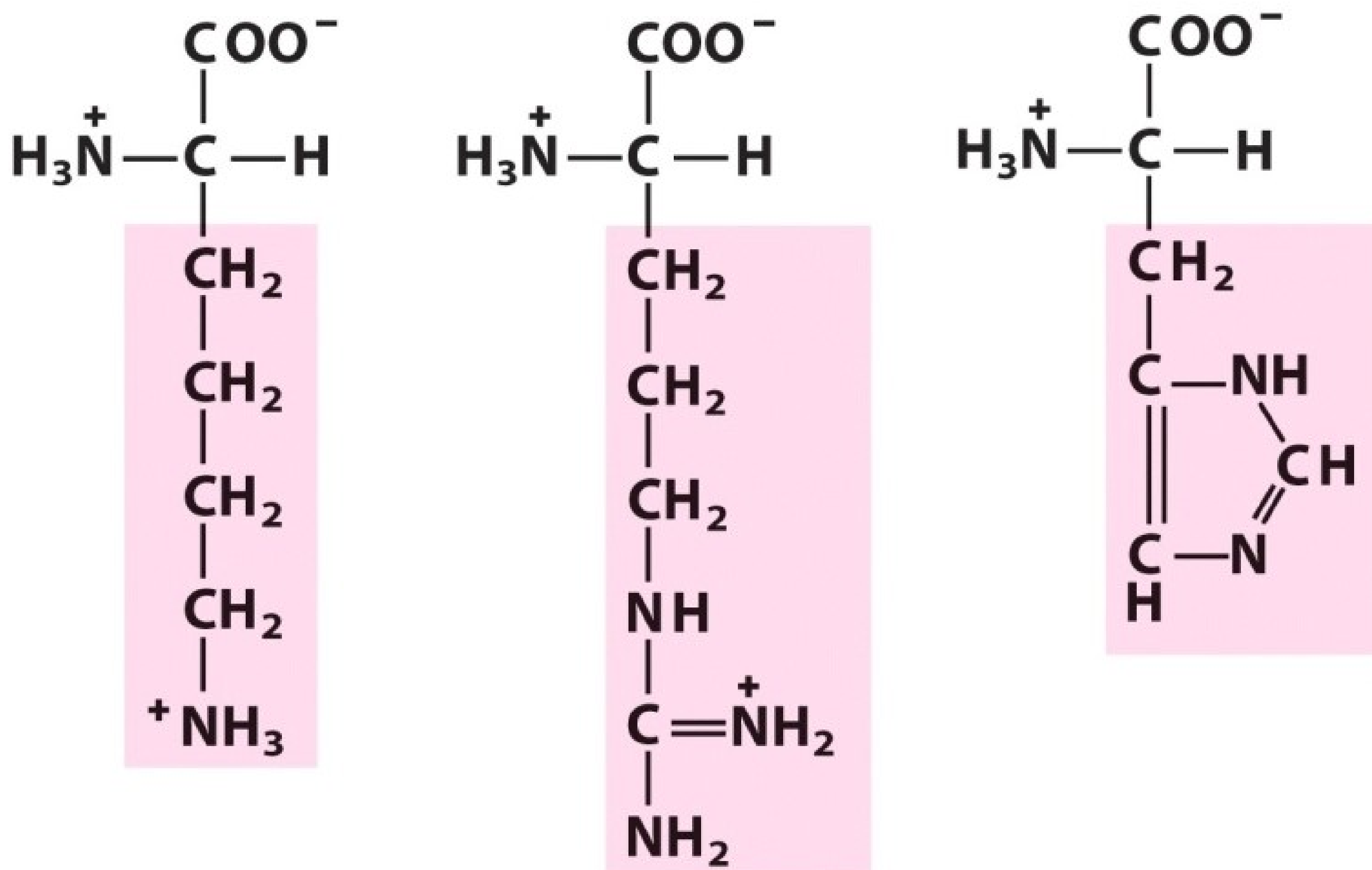
Positively charged R groups



Lysine Arginine Histidine

Essential amino acids

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Eight amino acids are generally regarded as essential for humans:
A good memonic device for remembering these is "Private Tim Hall", abbreviated as:
PVT TIM HALL:

Phenylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, Arginine, Lysine, Leucine

Essential amino acids

Eight amino acids are generally regarded as essential for humans:
A good memonic device for remembering these is "Private Tim Hall", abbreviated as:
PVT TIM HALL:

Valine, Leucine Isoleucine,
Phenylalanine(Ph), Tryptophan(Ph),
Threonine(OH), Methionine(s),
Lysine(B), Arginine(B),
Histidine(B),

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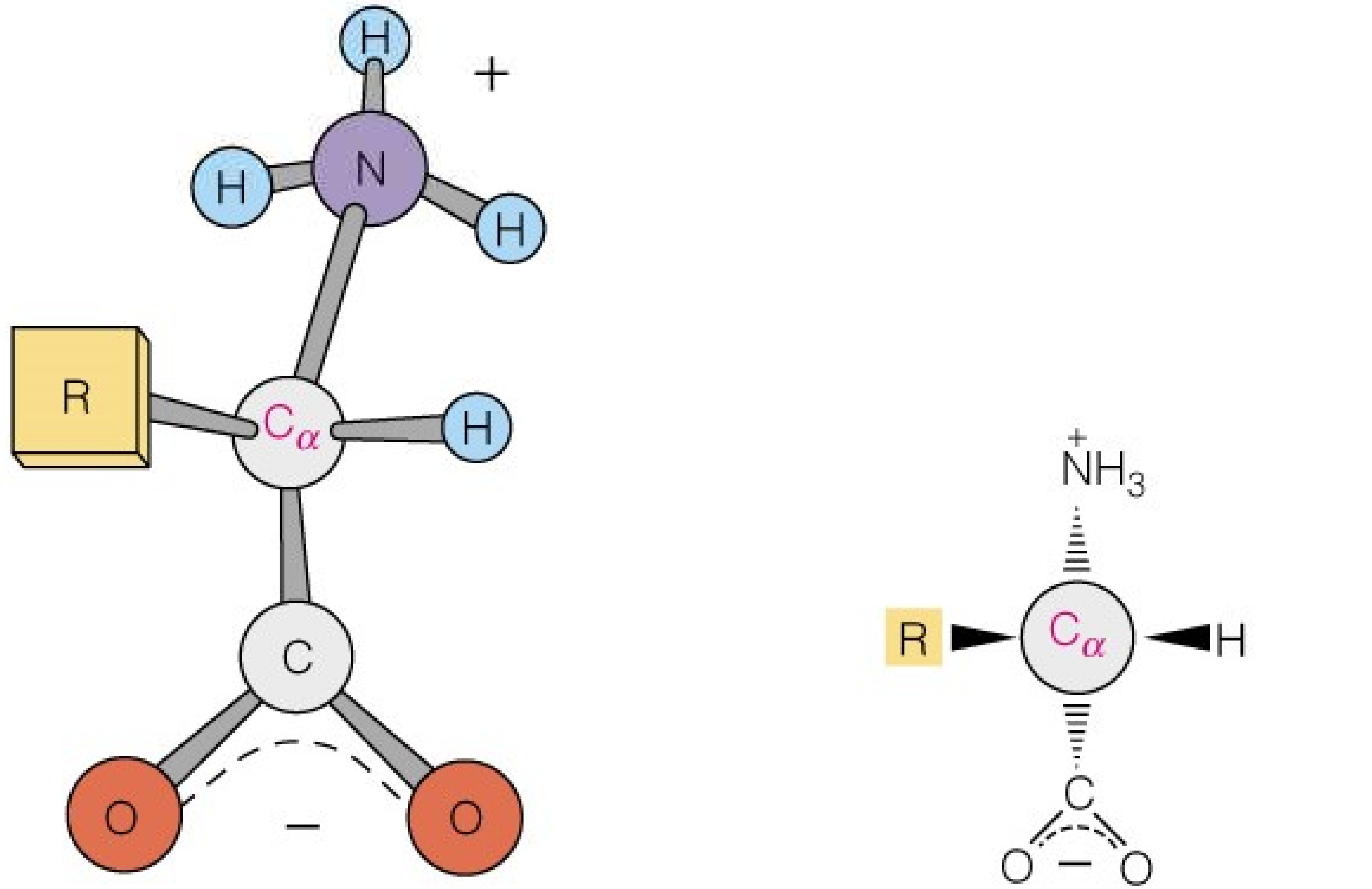
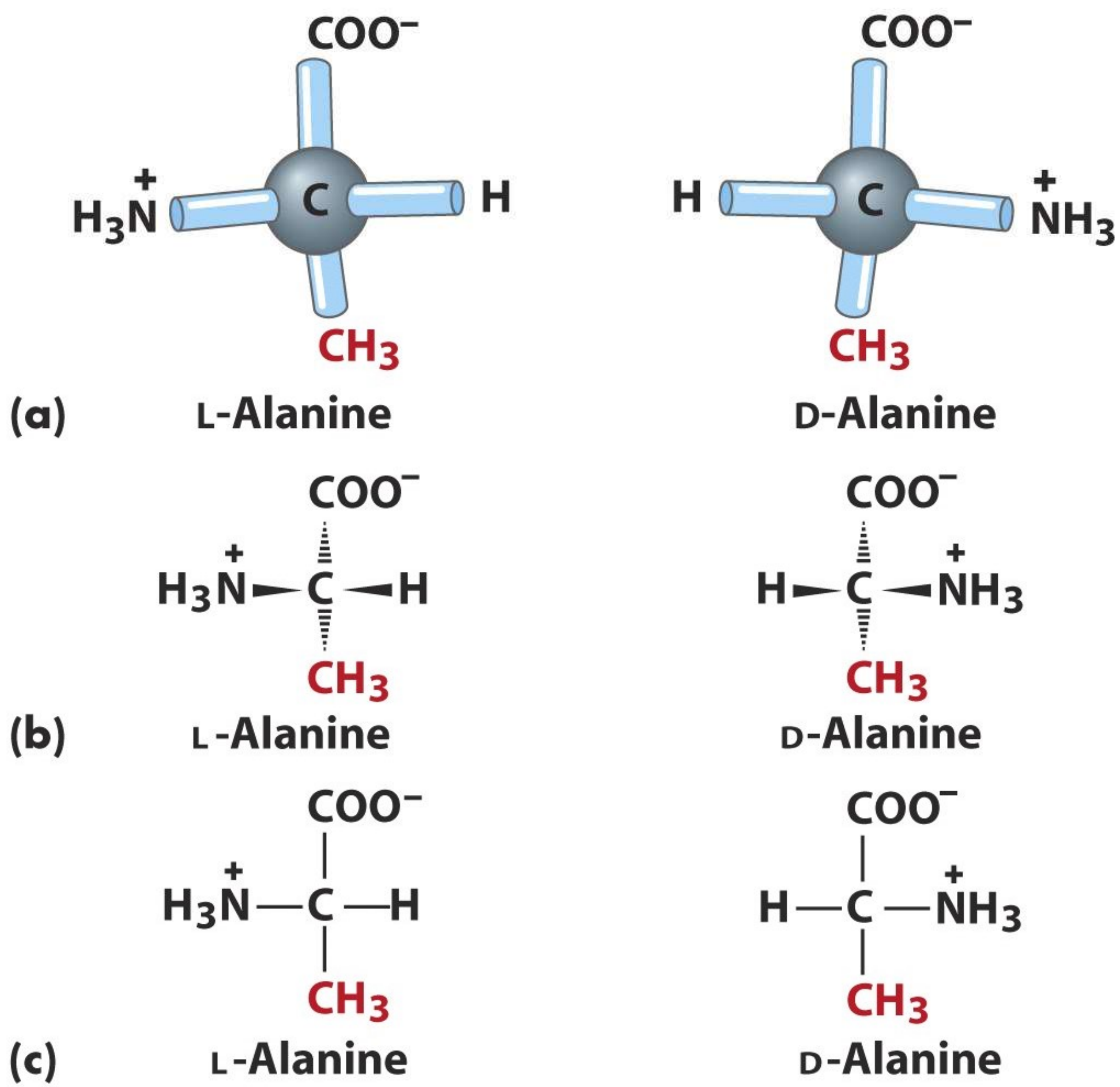
Stereochemistry



(a) α-Amino acid **(b)** Compact representation

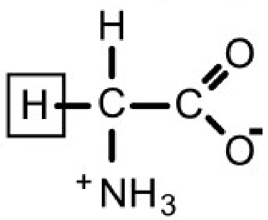
Stereoisomers



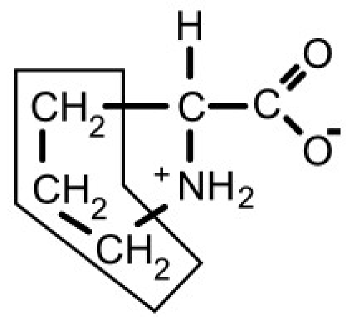
All amino acids in proteins are L-amino acids, except for glycine, which is achiral.

Non-polar amino acids

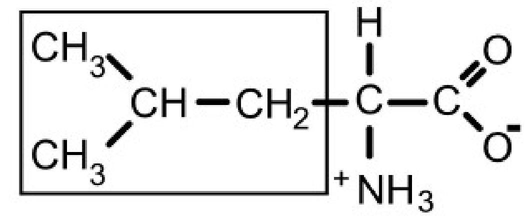
Glycine (Gly, G)



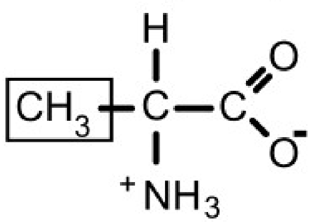
Proline (Pro, P)



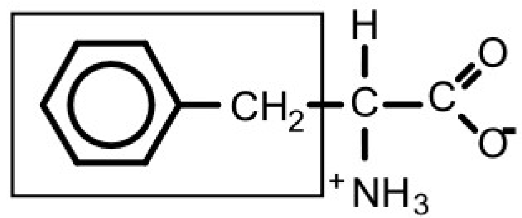
Leucine (Leu, L)



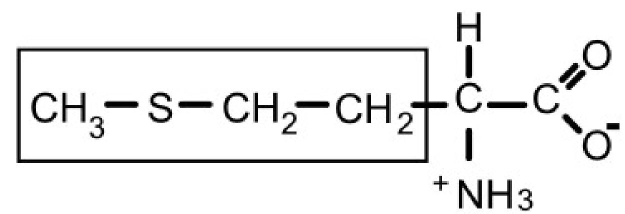
Alanine (Ala, A)



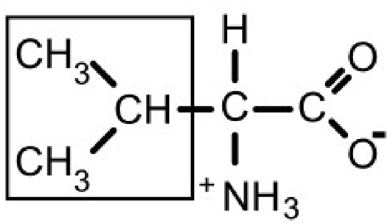
Phenylalanine (Phe, F)



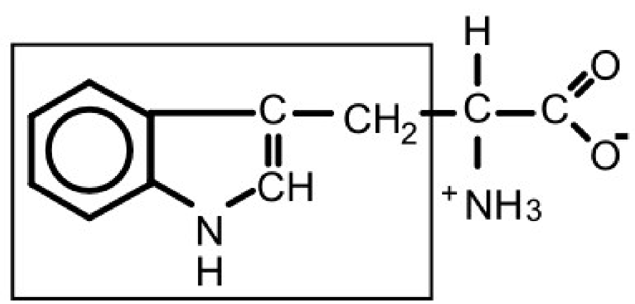
Methionine (Met, M)



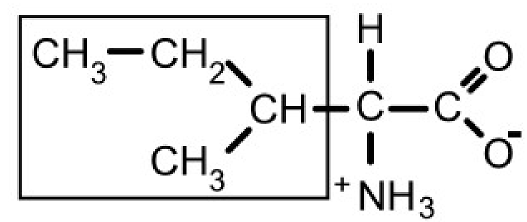
Valine (Val, V)



Tryptophan (Trp, W)

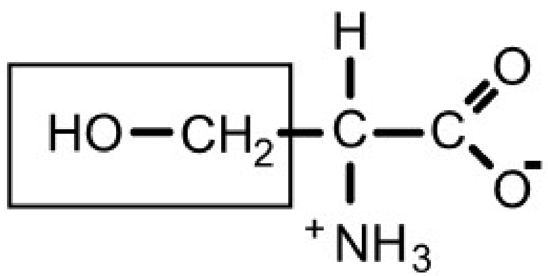


Isoleucine (Ile, I)

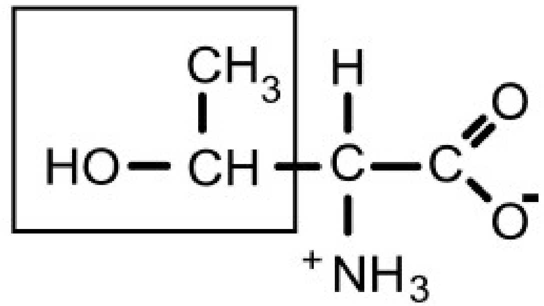


Polar, non-charged amino acids

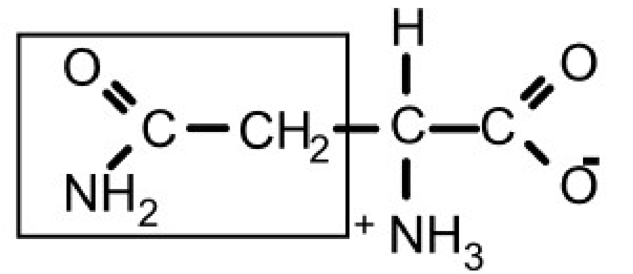
Serine (Ser, S)



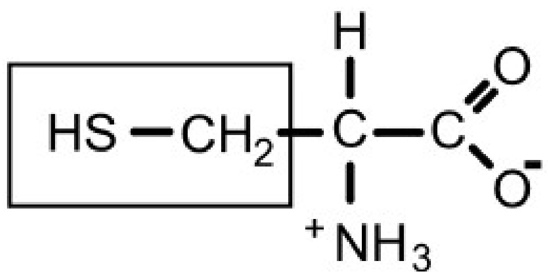
Threonine (Thr, T)



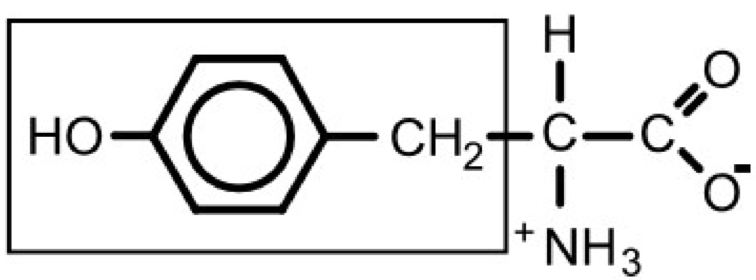
Asparagine (Asn, N)



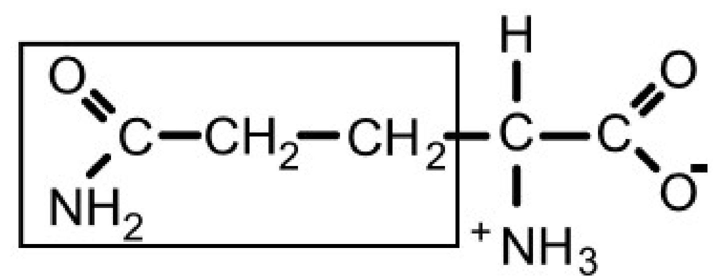
Cysteine (Cys, C)



Tyrosine (Tyr, Y)



Glutamine (Gln, Q)



Acidic amino acids

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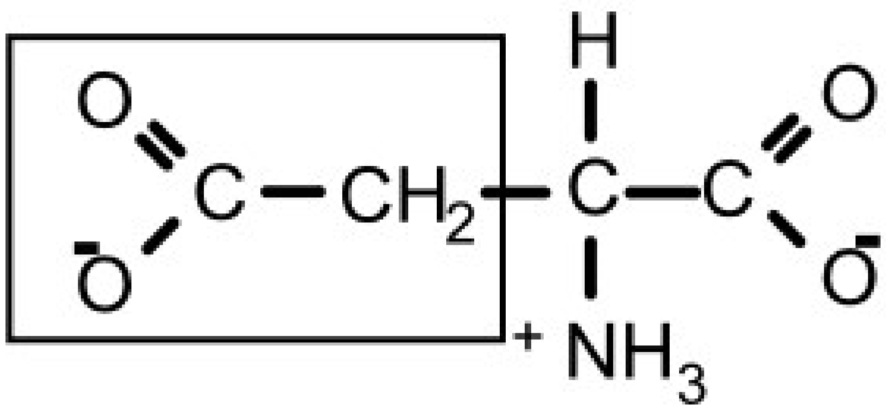
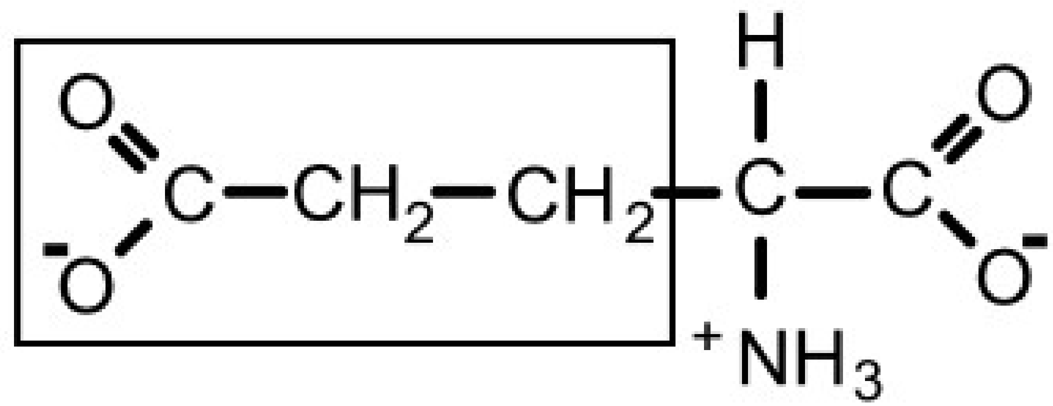
Aspartate (Asp, D)

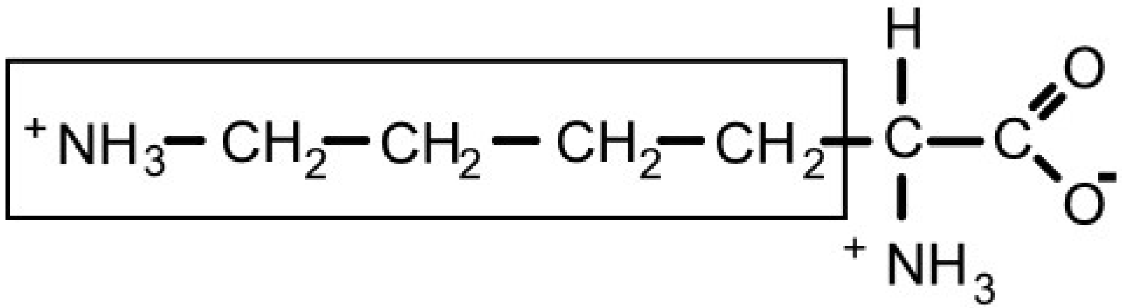


Glutamate (Glu, E)

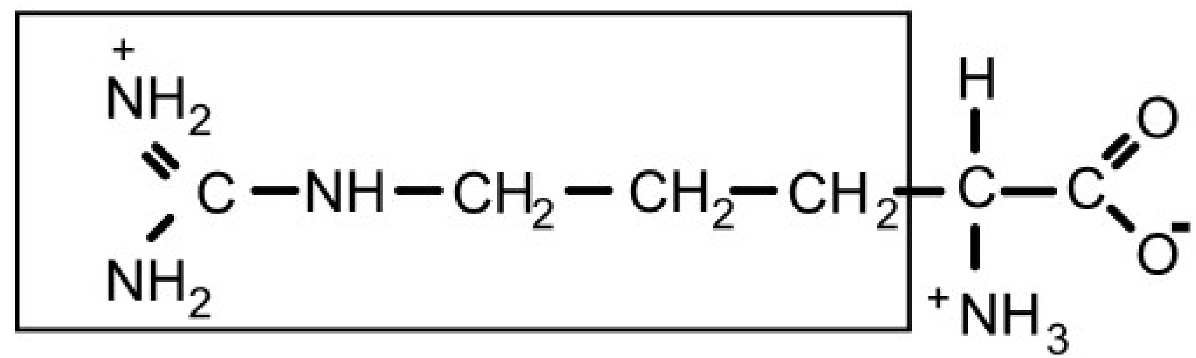


Basic amino acids

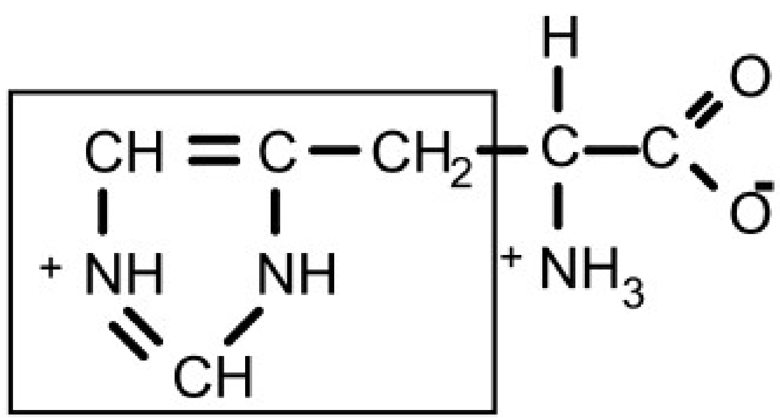
Lysine (Lys, K)



Arginine (Arg, R)



Histidine (His, H)
(protonated form)



Aromatic amino acids

To different degrees, all aromatic amino acids absorb ultraviolet light. Tryptophan is responsible for most of the absorbance of ultraviolet light (ca. 280 nm) by proteins. Tyrosine and tryptophan absorb more than do phenylalanine; Tyrosine is the only one of the aromatic amino acids with an ionizable side chain. Tyrosine is one of three hydroxyl containing amino acids.

Isoelectric Point

Isoelectric point (pI): pH at which an amino acid, polypeptide, or protein has a **total charge** of zero.

The pI for glycine, for example, falls between the pK_a values for the carboxyl and amino groups.

$$pI = \frac{1}{2}\,(pK_a\ \alpha\text{–COOH} + pK_a\ \alpha\text{–}NH_3^{+})$$

$$= \frac{1}{2}\,(2.35 + 9.78) = 6.06$$

Isoelectric Point of glycine continued

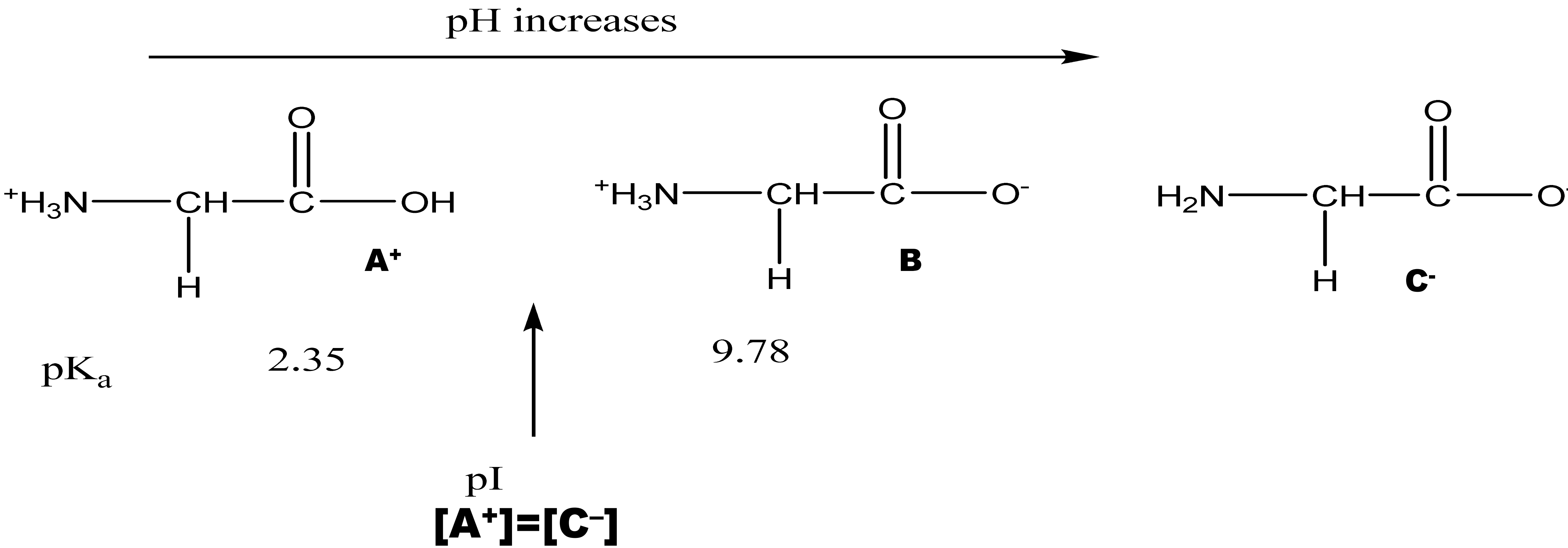
Again

$$pI = \frac{1}{2}\left(pK_a\ \alpha\text{–COOH} + pK_a\ \alpha\text{–NH}_3^{+}\right)$$

$$= \frac{1}{2}(2.35 + 9.78) = 6.06$$

Isoelectric Point

By.
S.K.Sinha



Isoelectric Point

Acidic Side Chains	pK_a of α–COOH	pK_a of α–NH_3^+	pK_a of Side Chain	pI
aspartic acid	2.10	9.82	3.86	2.98
glutamic acid	2.10	9.47	4.07	3.08
cysteine	2.05	10.25	8.00	5.02
tyrosine	2.20	9.11	10.07	5.63

Basic Side Chains	pK_a of α–COOH	pK_a of α–NH_3^+	pK_a of Side Chain	pI
arginine	2.01	9.04	12.48	10.76
histidine	1.77	9.18	6.10	7.64
lysine	2.18	8.95	10.53	9.74

Isoelectric Point

By. S.K.Sinha

Amino acid	Abbrev.	pI	pK1 (α-COOH)	pK2 (α-+NH3)
Alanine	Ala	6.01	2.35	9.87
Cysteine	Cys	5.05	1.92	10.7
Aspartic acid	Asp	2.85	1.99	9.9
Glutamic acid	Glu	3.15	2.1	9.47
Phenylalanine	Phe	5.49	2.2	9.31
Glycine	Gly	6.06	2.35	9.78
Histidine	His	7.6	1.8	9.33
Isoleucine	Ile	6.05	2.32	9.76

Isoelectric Point

By. S.K.Sinha

Amino acid	Abbrev.	pI	pK1 (α-COOH)	pK2 (α-+NH3)
Lysine	Lys	9.6	2.16	9.06
Leucine	Leu	6.01	2.33	9.74
Methionine	Met	5.74	2.13	9.28
Asparagine	Asn	5.41	2.14	8.72
Proline	Pro	6.3	1.95	10.64
Glutamine	Gln	5.65	2.17	9.13
Arginine	Arg	10.76	1.82	8.99

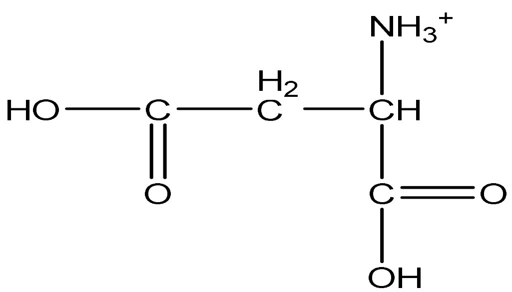
Isoelectric Point

By.
S.K.Sinha

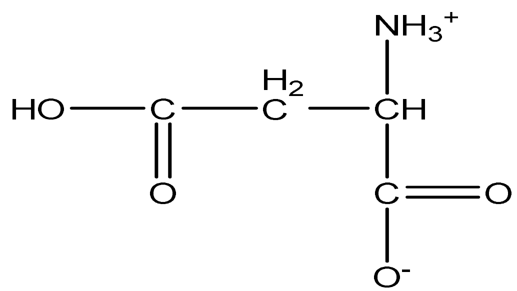
Amino acid	Abbrev.	pI	pK1 (α-COOH)	pK2 (α-+NH3)
Serine	Ser	5.68	2.19	9.21
Threonine	Thr	5.6	2.09	9.1
Valine	Val	6	2.39	9.74
Tryptophan	Trp	5.89	2.46	9.41
Tyrosine	Tyr	5.64	2.2	9.21

Aspartic acid

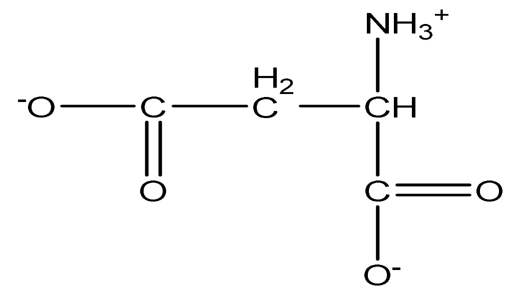
A^+



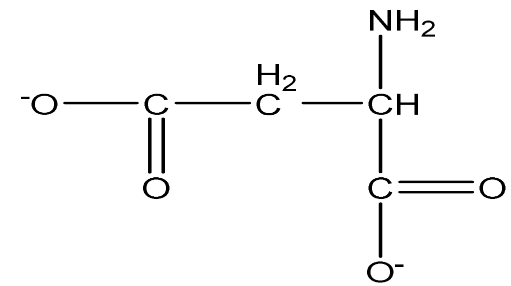
B



C^-



D^{2-}



pK_a 2.10 3.86 9.82

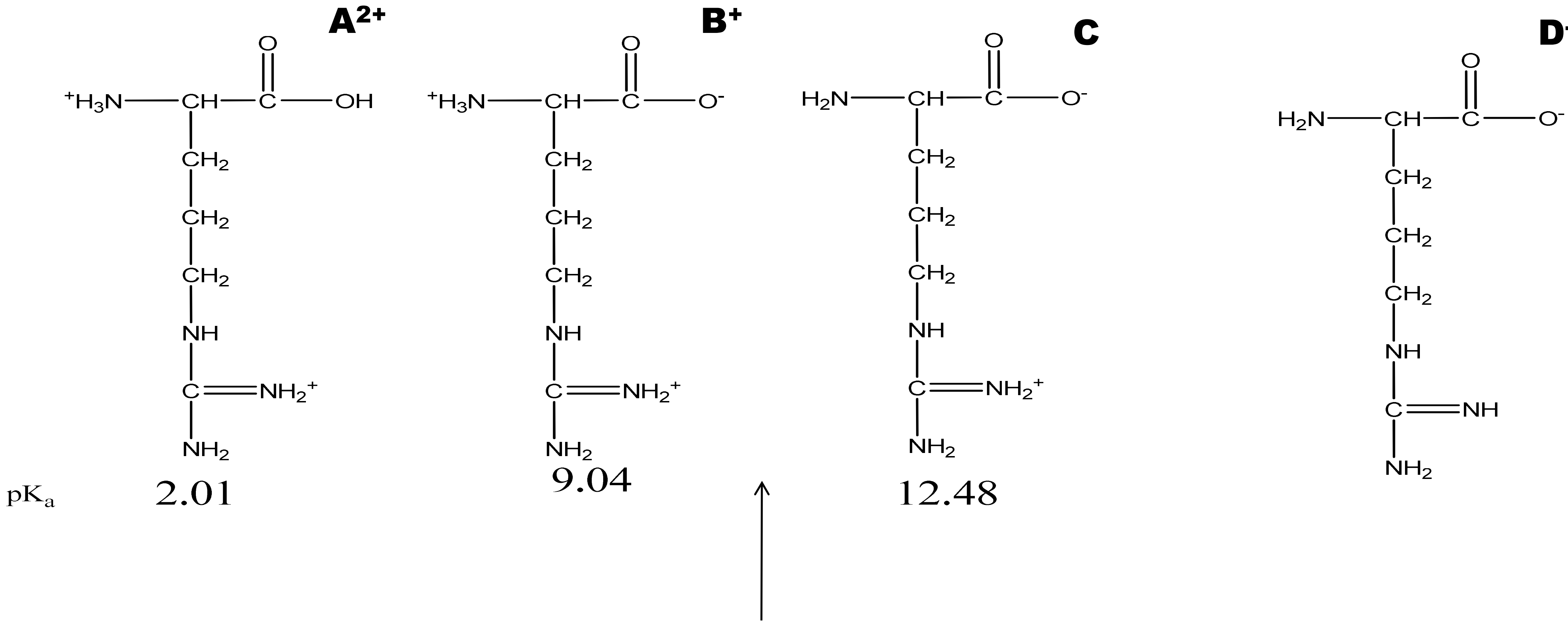
$pH = pK_a$

$[A^+] = [B]$ $[B] = [C^-]$

$pI = (2.10 + 3.86)/2$
$[A^+] = [C^-]$
$[D^{2-}]$ approx 0

Note species B has zero net charge. pK_a1 and pK_a2 control $[A^+]$ and $[C^-]$ which should be equal.

Arginine



pI = (9.04+12.48)/2 =10.76
[B⁺] = [D⁻]; [A²⁺] about 0

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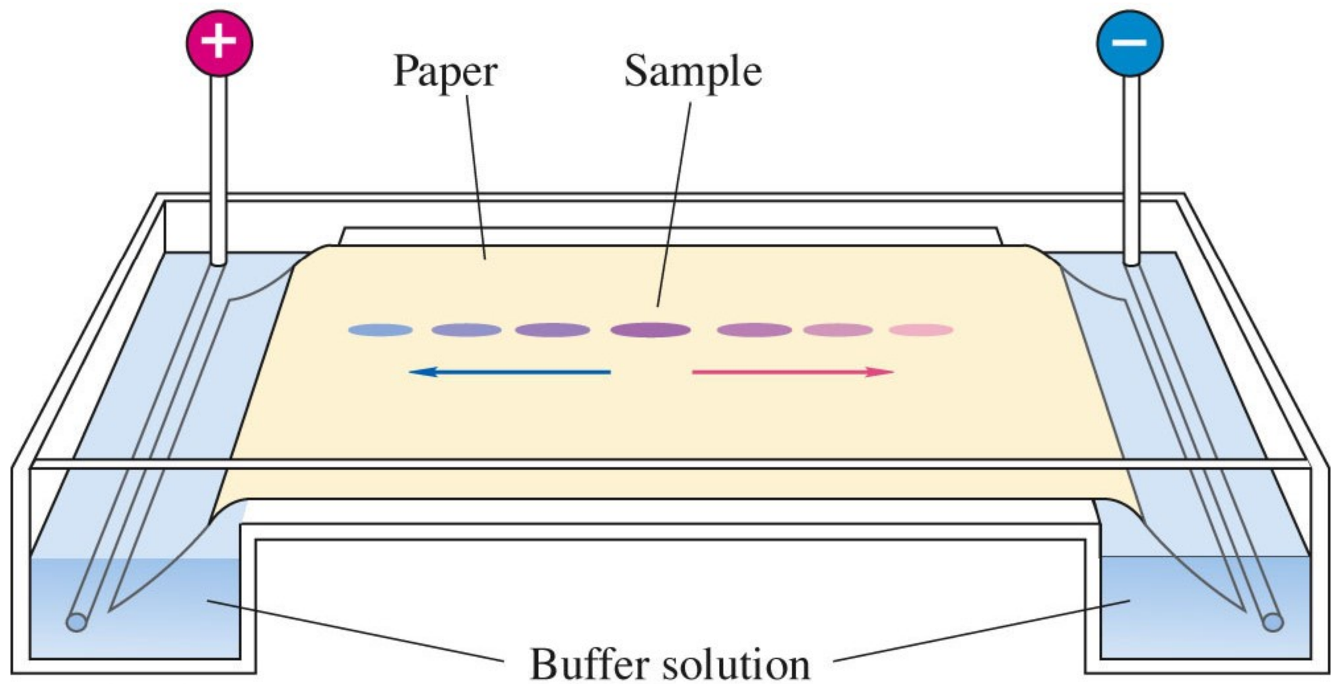
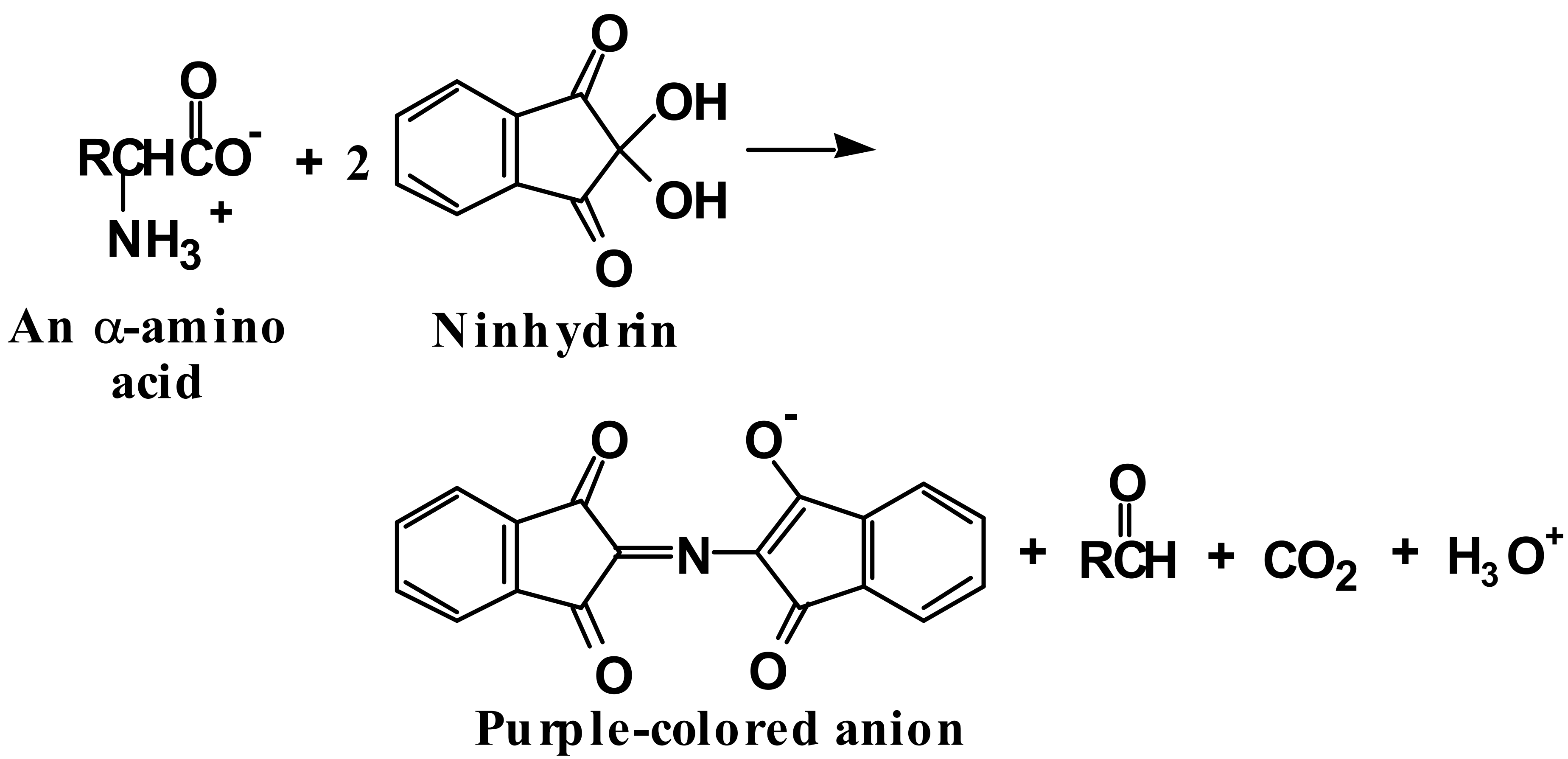
Electrophoresis

Electrophoresis: **The process of separating compounds on the basis of their electric charge. Electrophoresis of amino acids can be carried out using paper, starch, polyacrylamide and agarose gels, and cellulose acetate as solid supports.**



Ninhydrin

The reagent commonly used to detect amino acid is ninhydrin.



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General protein pK’ values

Group	Approximate pK' In a “Typical” Protein
α-carboxyl (free)	3 (C-terminal only)
β-carboxyl (Asp)	4
γ-carboxyl (Glu)	4
imidazole (His)	6
sulfhydryl (Cys)	8
1°α-amino (free)	8 (N-terminal only)
ε-amino (Lys)	10
hydroxyl (Tyr)	10
2°α-amino (Pro)	9 (N-terminal only)
guanido (Arg)	12

Levels of Protein Structure

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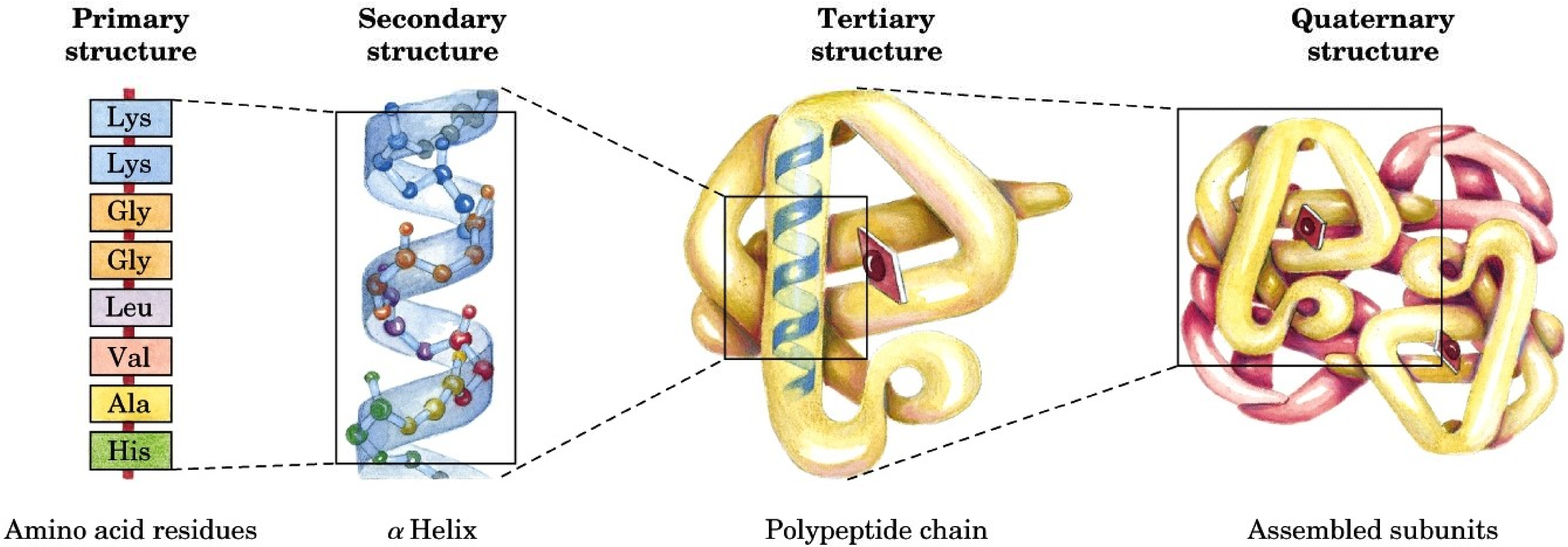


Levels of Protein Structure

Proteins show 4 levels of structural organisation:

1.Primary structure = amino acid sequence

- **Determined by the genetic code of the mRNA.**

2. Secondary structure = folding and twisting of a single polypeptide chain.

- **Result of weak H-bond and electrostatic interactions.**
- **e.g., α-helix (coiled) and β-pleated sheet (zig-zag).**

Levels of Protein Structure

S.K.Sinha

3. Tertiary structure = three dimensional shape (or conformation) of a polypeptide chain.

- **Function of R groups contained in the polypeptide.**

4. Quaternary structure = association between polypeptides in multi-subunit proteins (e.g. hemoglobin).

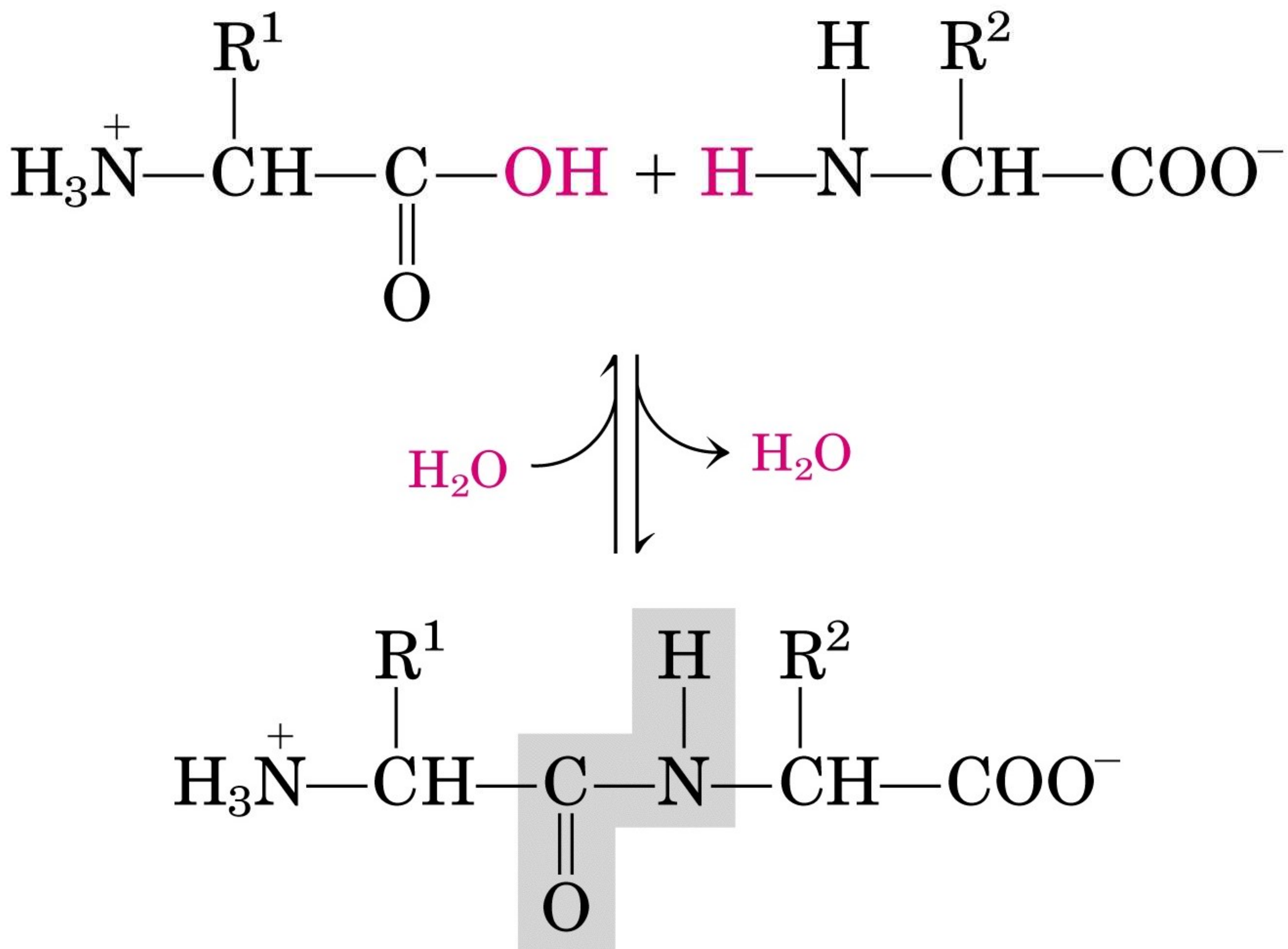
- **Occurs only with two or more polypeptides.**

Peptide Bonds

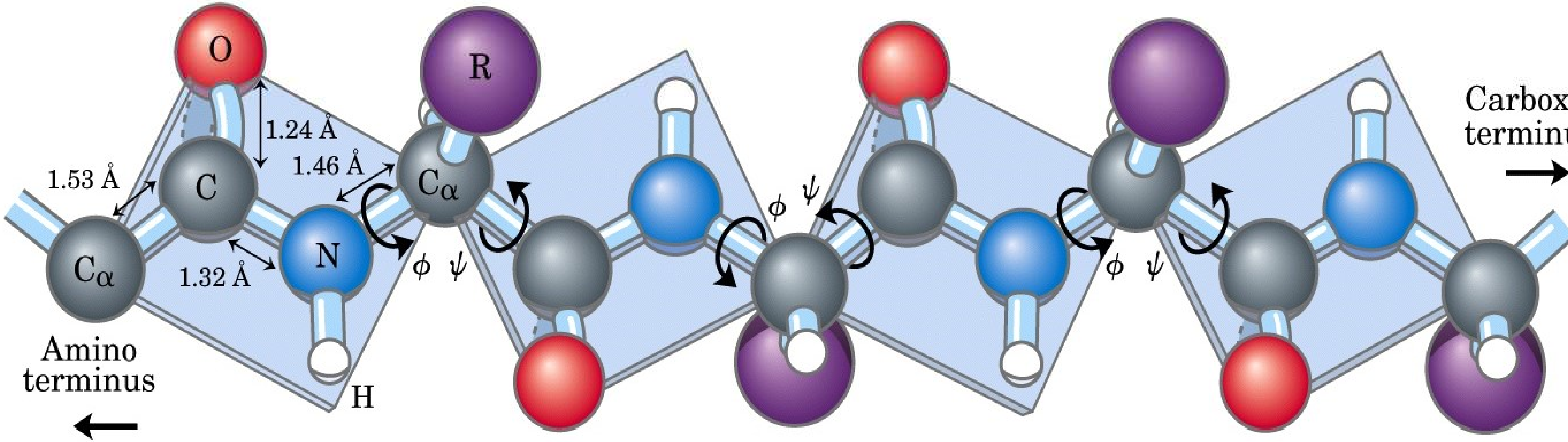
–α-carboxyl of one amino acid is joined to α-amino of a second amino acid (with removal of water)

- only α-carboxyl and α-amino groups are used, not R-group carboxyl or amino groups.

Peptide bond formation



The peptide bond is planar



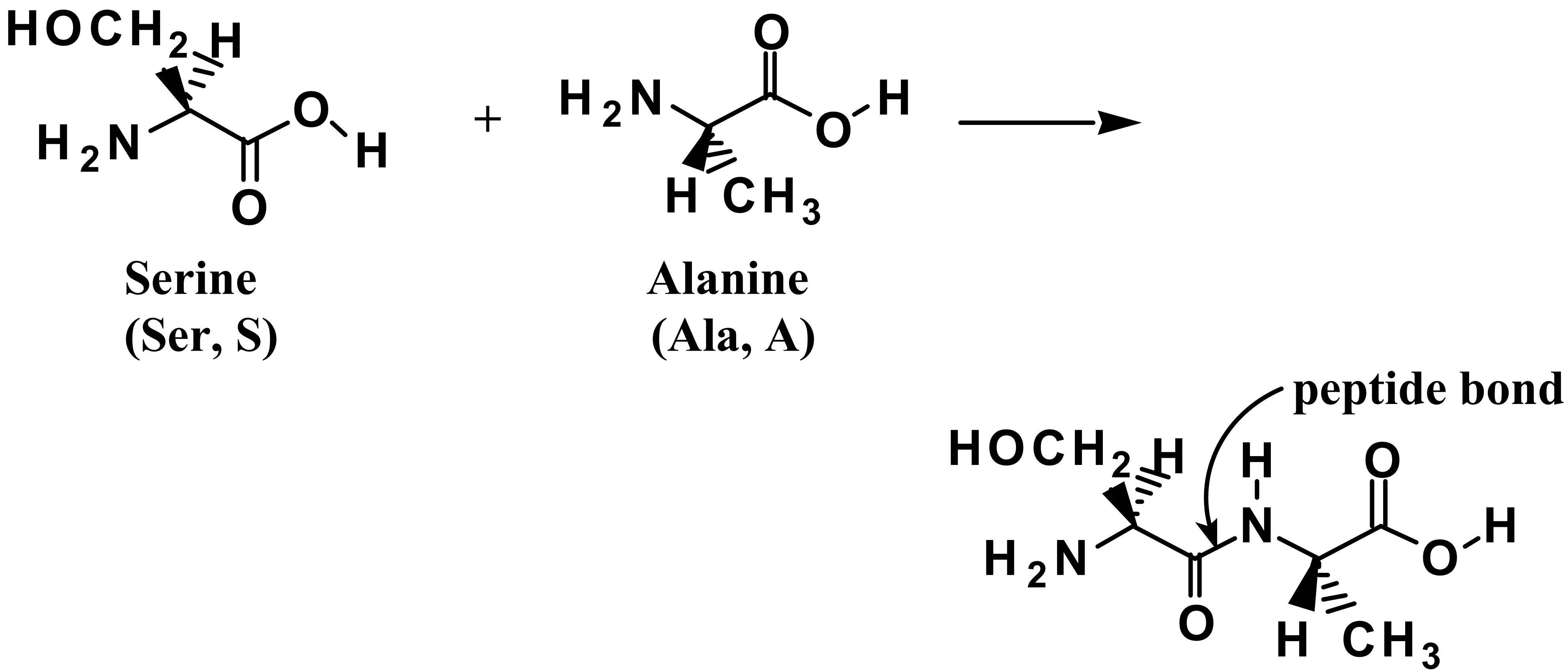
This resonance restricts the number of conformations in proteins -- main chain rotations are restricted to ϕ and ψ.

Polypeptides & Proteins

In 1902, Emil Fischer proposed that proteins are long chains of amino acids joined by amide bonds to which he gave the name peptide bonds.

Peptide bond: The special name given to the amide bond between the α-carboxyl group of one amino acid and the α-amino group of another.

Serinylalanine (Ser-Ala)



Serinylalanine
(Ser-Ala, (S-A)

Peptides

Peptide: **The name given to a short polymer of amino acids joined by peptide bonds; they are classified by the number of amino acids in the chain.**

Dipeptide: **A molecule containing two amino acids joined by a peptide bond.**

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Peptides

Tripeptide: A molecule containing three amino acids joined by peptide bonds.

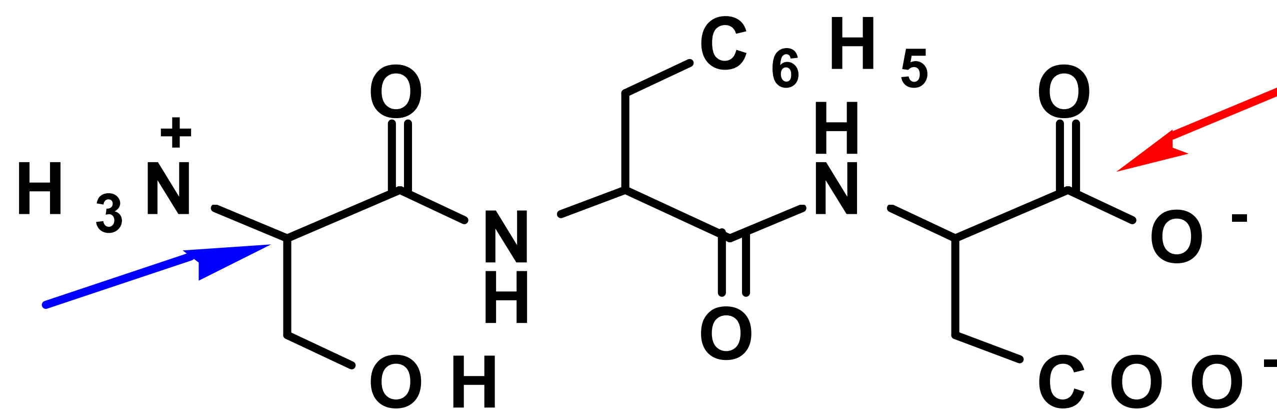
Polypeptide: A macromolecule containing many amino acids joined by peptide bonds.

Peptides

Protein: **A biological macromolecule of molecular weight 5000 g/mol or greater, consisting of one or more polypeptide chains.**

Writing Peptides

By convention, peptides are written from the left, beginning with the free -NH_3^+ group and ending with the free -COO^- group on the right.



N-terminal amino acid

C-terminal amino acid

Ser-Phe-Asn

THANK YOU for WATCHING

Do SHARE your FEEDBACK With US