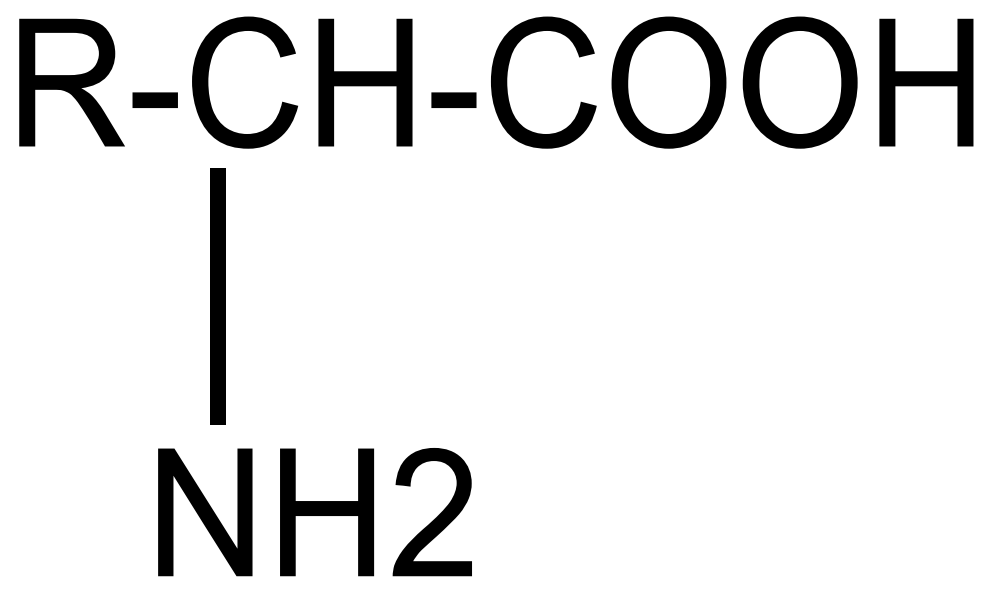
بیوشیمی عمومی

دکتر حمید رضا جوشقانی

اسیدهای آمینه

ساختمان عمومي اسيدهاي آمينه

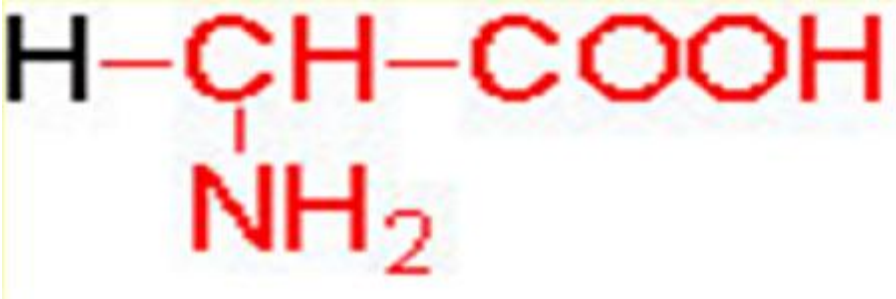


اسيدهاي آمينه ضروري و غير ضروري

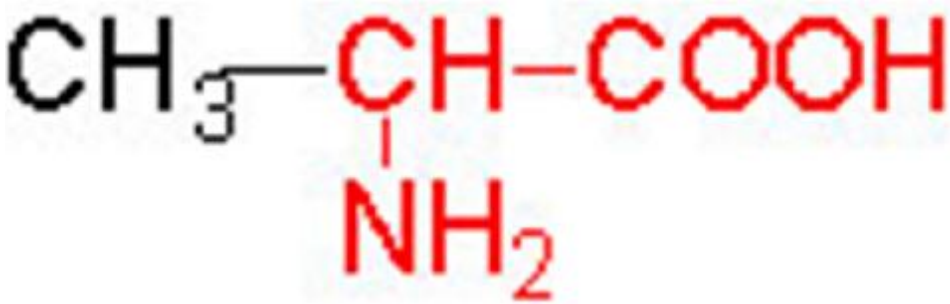
Nonessential	Essential
Alanine	Arginine*
Asparagine	Histidine*
Aspartate	Isoleucine
Cysteine	Leucine
Glutamate	Lysine
Glutamine	Methionine
Glycine	Phenylalanine
Proline	Threonine
Serine	Tyrptophan
Tyrosine	Valine

اسيدهاي آمينه با زنجيرهٔ جانبي آليفاتيك

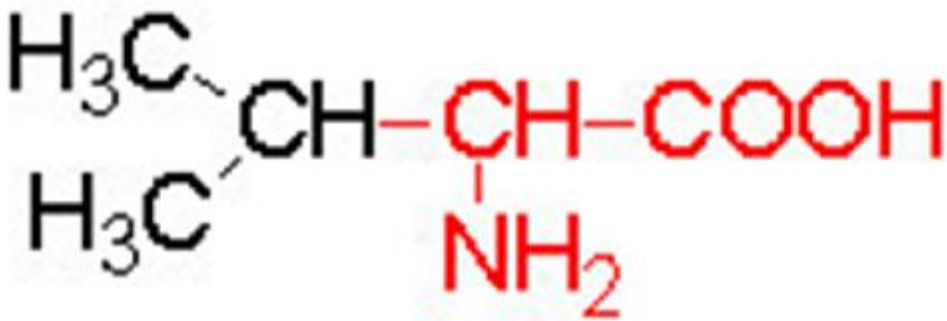
Glycine (Gly – G)



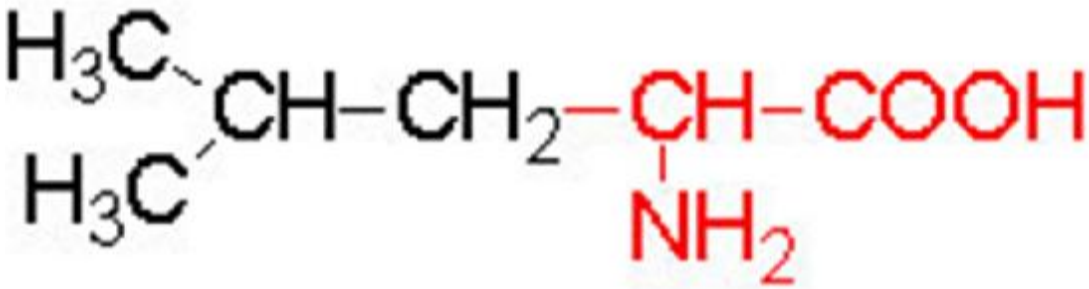
Alanine (Ala – A)



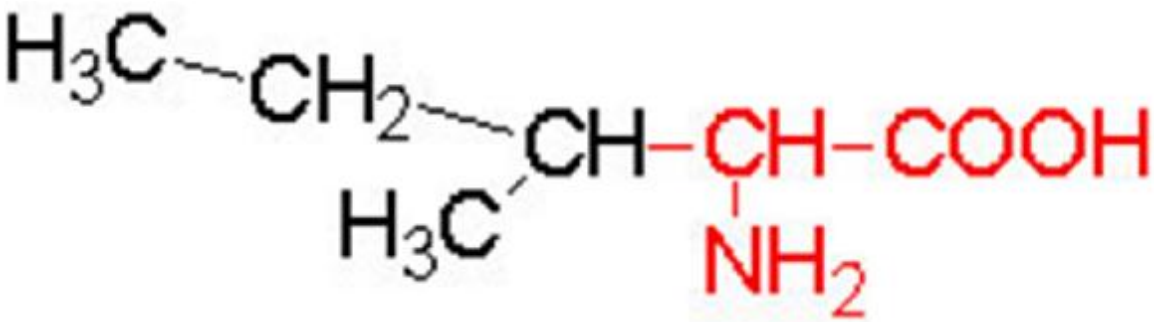
Valine (Val – V)



Leucine (Leu – L)

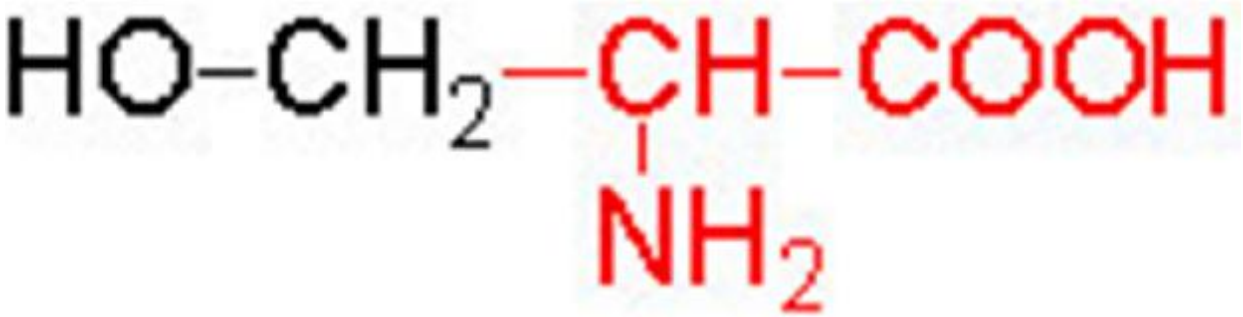


Isoleucine (Ile-I)

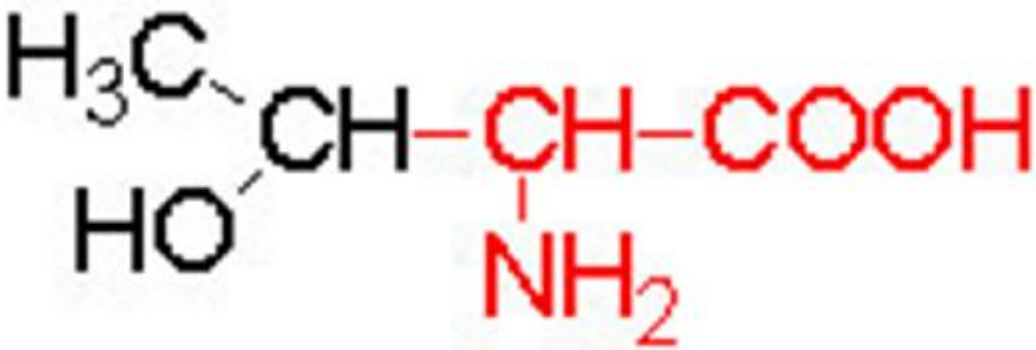


اسيدهاي آمينه الكلي غير حلقوي

Serine (Ser- S)

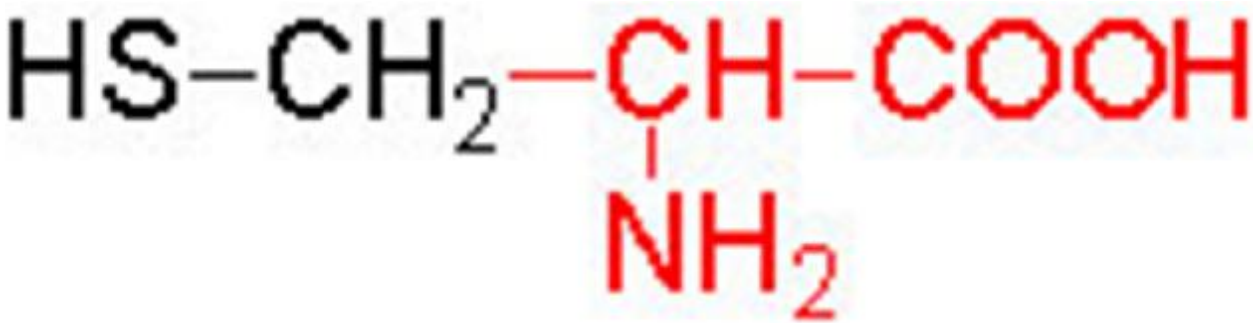


Threonine (Thr-T)

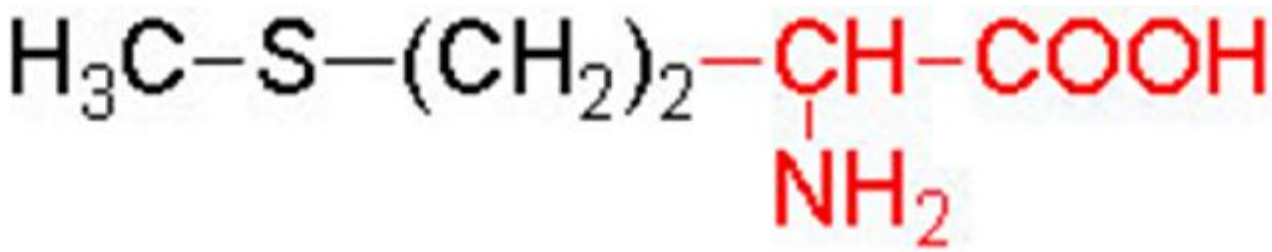


اسيدهاي آمينه گوگرد دار

Cysteine (Cys-C)

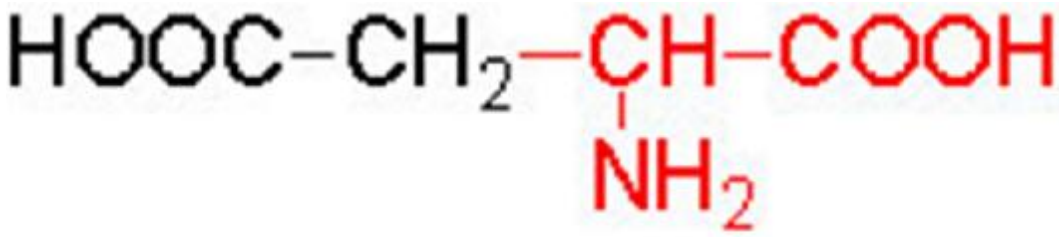


Methionine (Met-M)

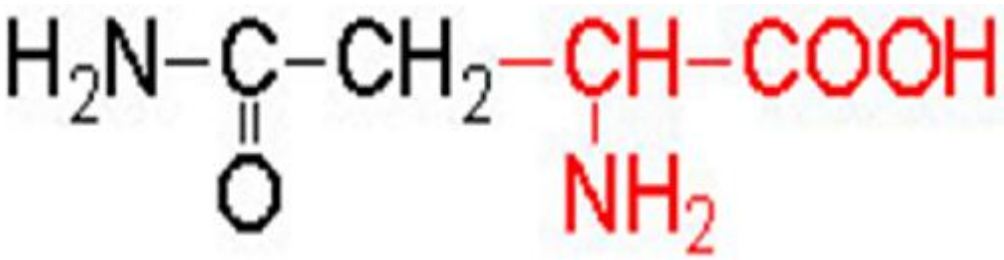


اسيدهاي آمينه اسيدي با آميدهاي مربوطه

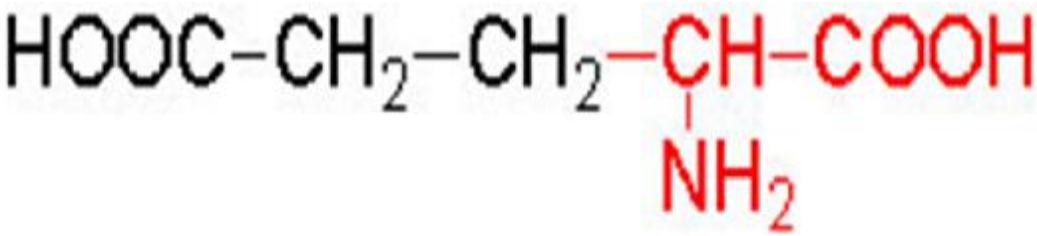
Aspartic Acid (Asp-D)



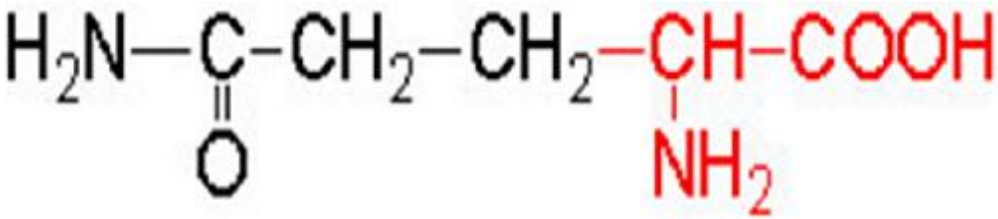
Asparagine (Asn-N)



Glutamic Acid (Glu-E)

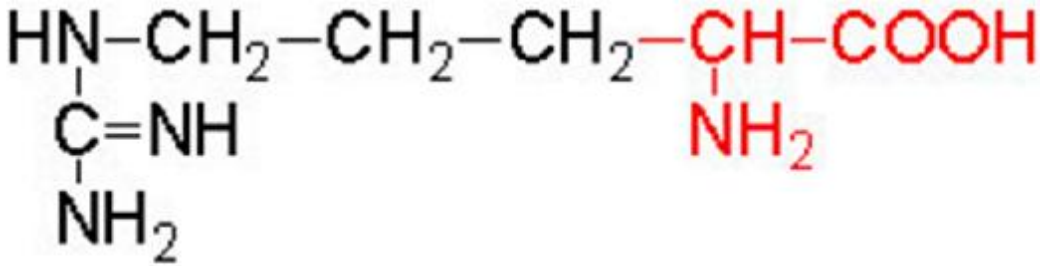


Glutamine (Gln-Q)

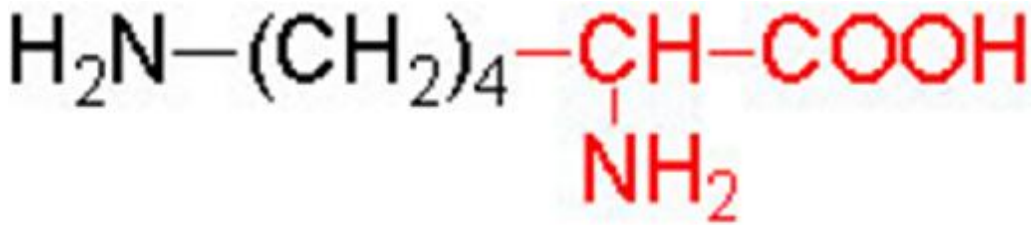


اسيدهاي آمينه قليايي

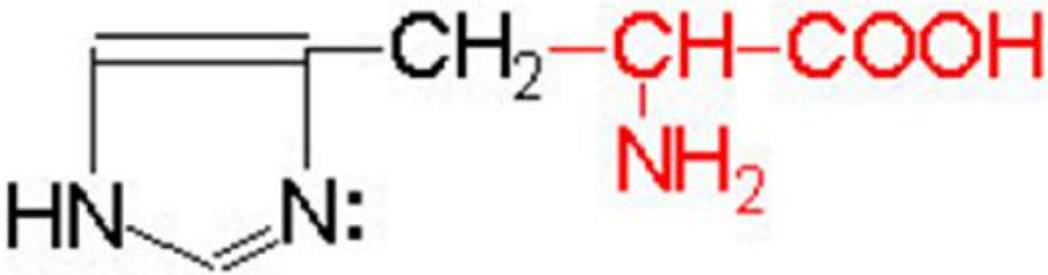
Arginine (Arg-R)



Lysine (Lys-K)

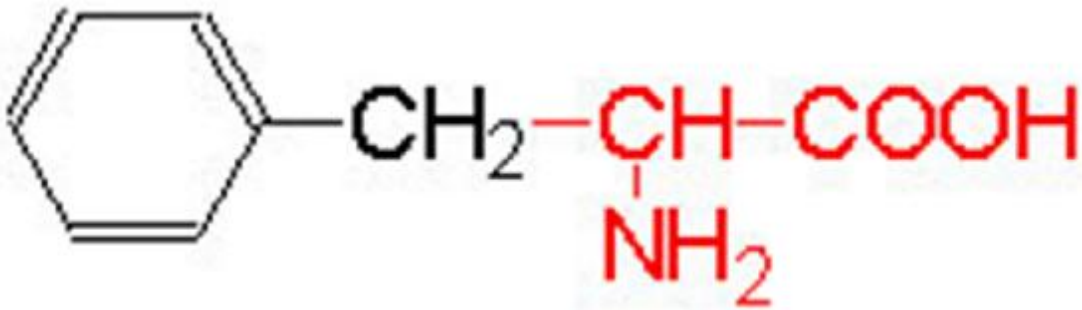


Histidine (His-H)

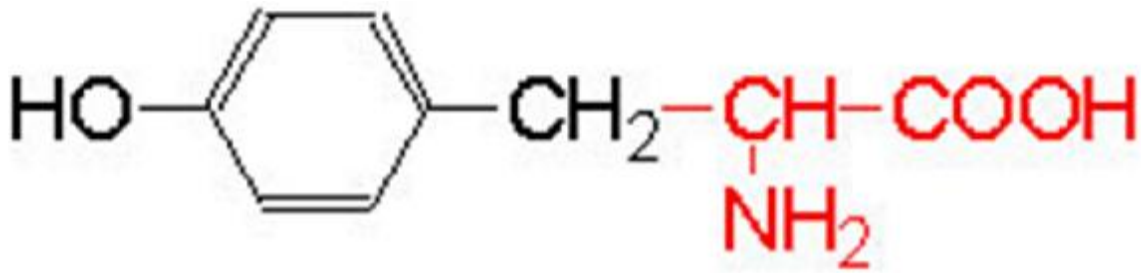


اسيدهاي آمينه آروماتيك

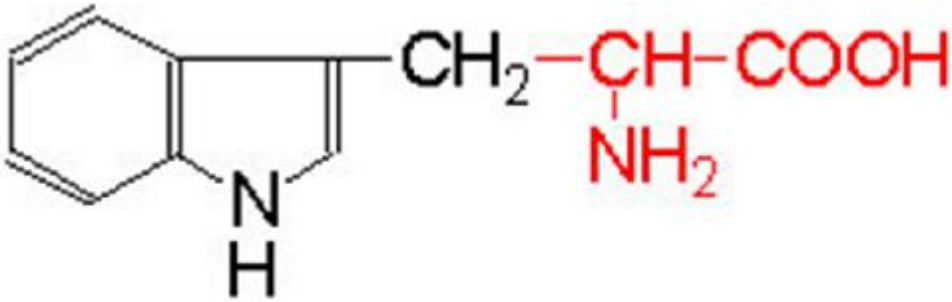
Phenylalanine (Phe-F)



Tyrosine (Tyr-Y)

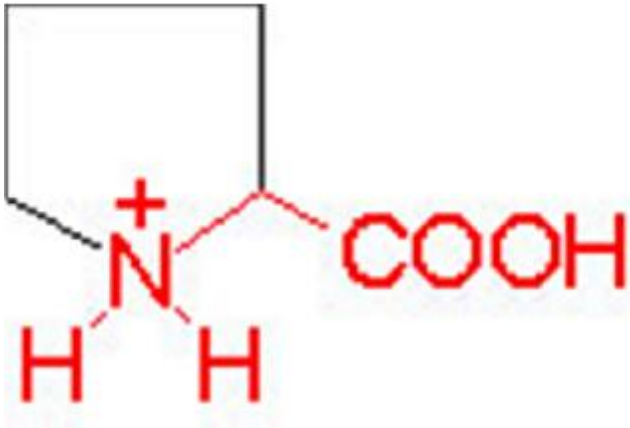


Tryptophan (Trp-W)



ایمینواسید

Proline (Pro-P)



ساختمان اسيدهاي آمينه

ایزومر L و D

```
        COOH                COOH
         |                   |
2HN - C - H          H - C - NH2
         |                   |
        CH3                 CH3
```

pH ایزوالکتریک

اسيدهاي آمينه‌اي كه داراي يك عامل كربوكسيل و يك عامل آمين هستند

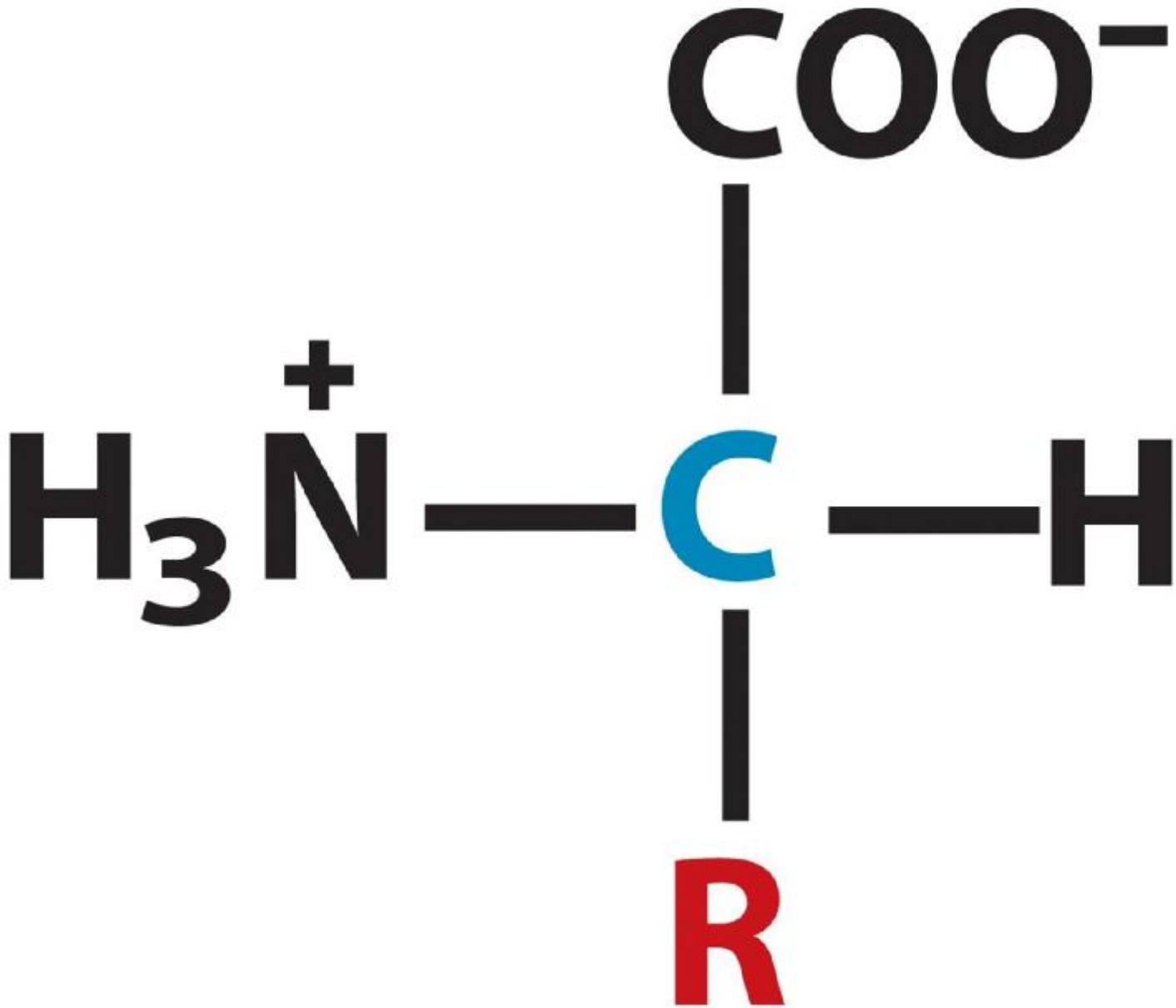
$$PI = \frac{PK_1 + PK_2}{2}$$

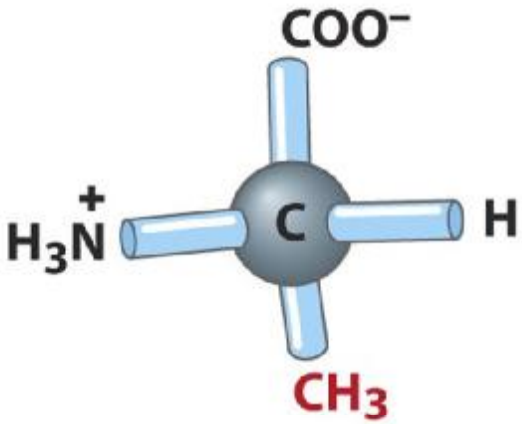
اسيدهاي آمينه‌اي كه در ريشه جانبي خود يك عامل اسيدي دارند

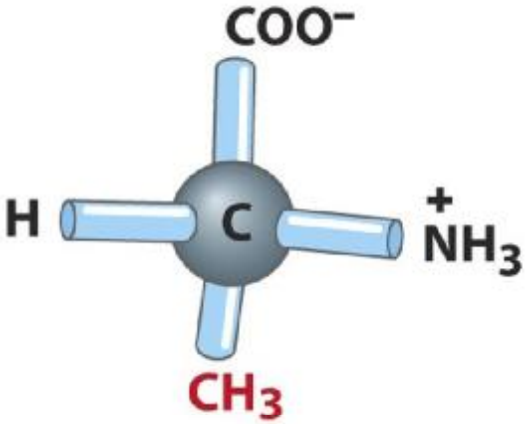
$$PI = \frac{PK_1 + PK_3}{2}$$

اسيدهاي آمينه‌اي كه در ريشه جانبي خود داراي عامل آمين هستند

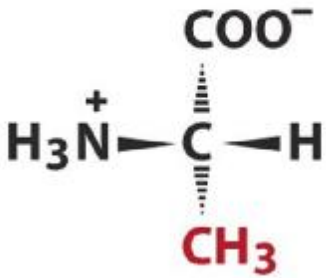
$$PI = \frac{PK2 + PK3}{2}$$

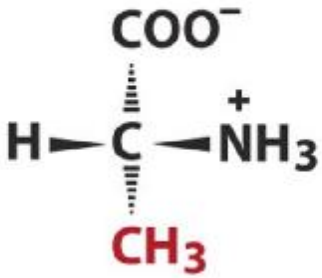

COO⁻
H3N+
C
H
R



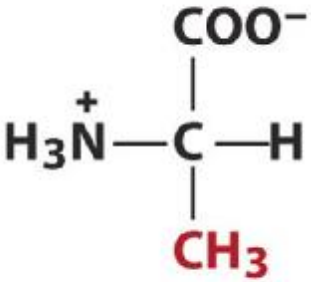


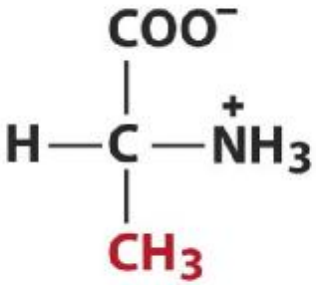
(a) L-Alanine D-Alanine



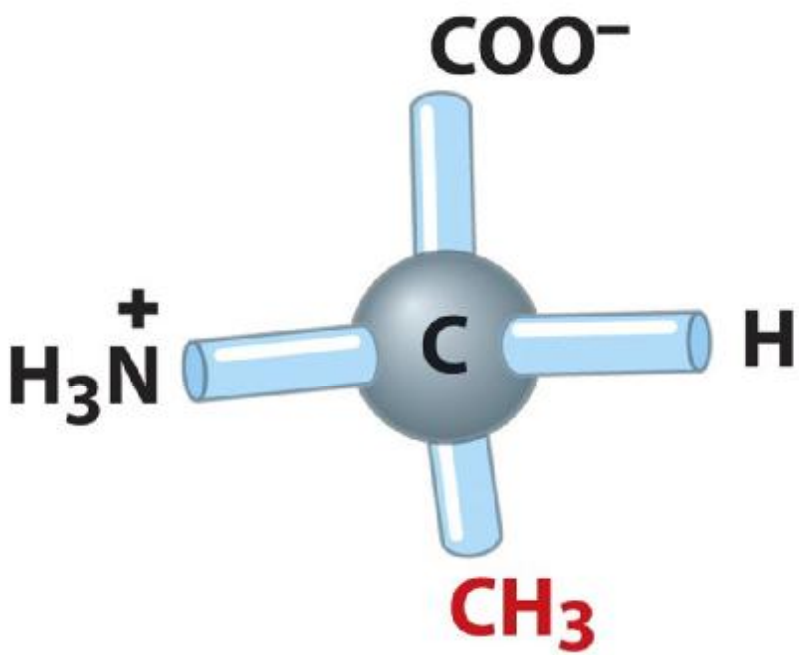


(b) L-Alanine D-Alanine

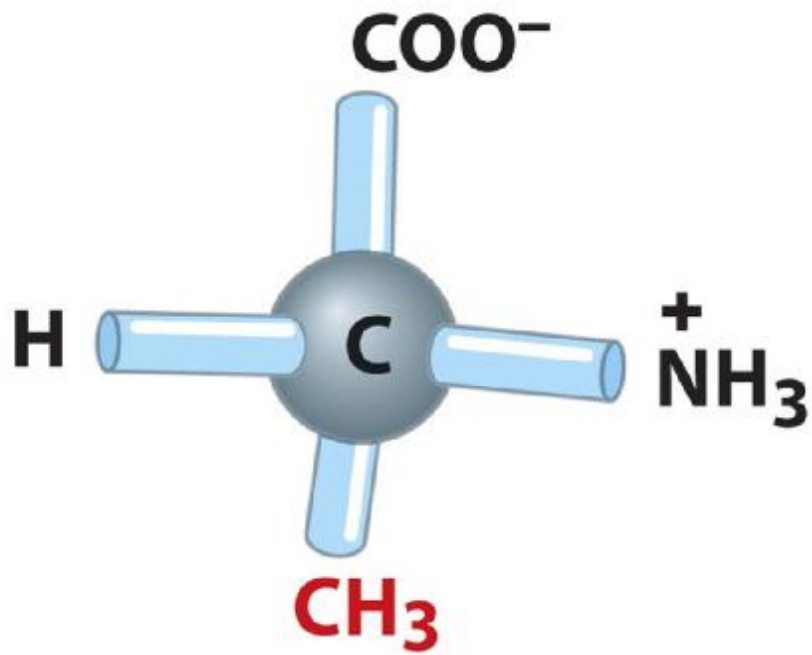




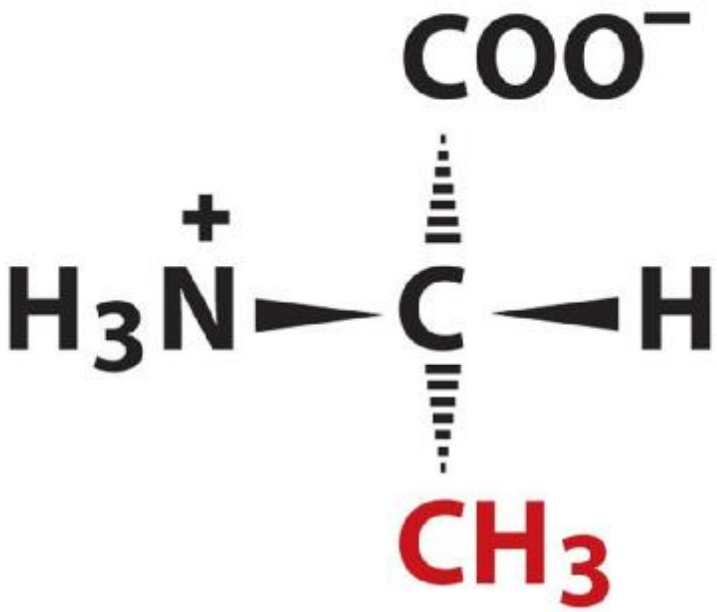
(c) L-Alanine D-Alanine



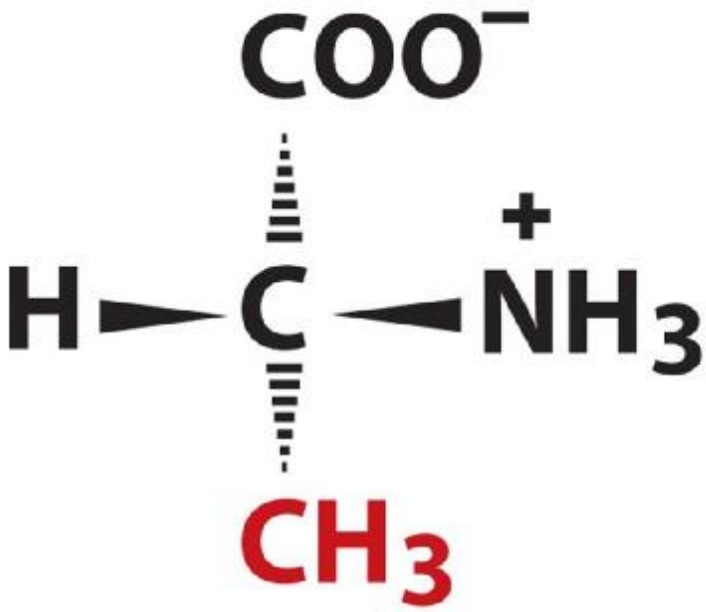
L-Alanine



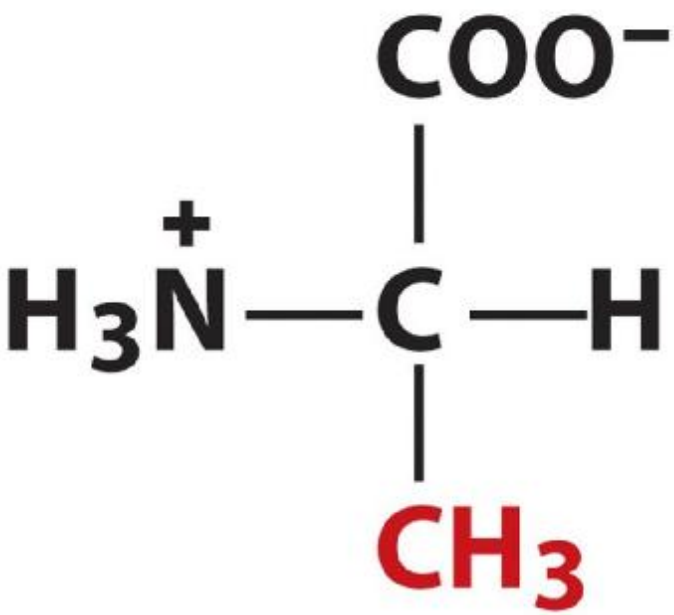
D-Alanine



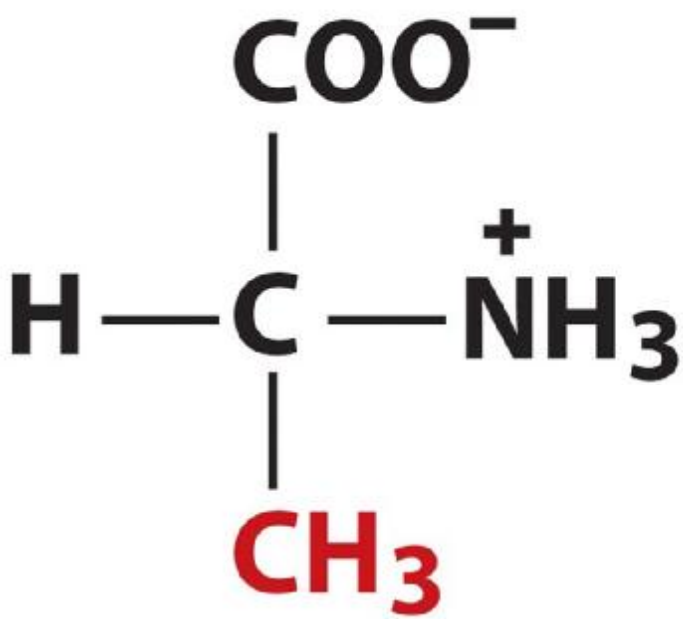
L-Alanine



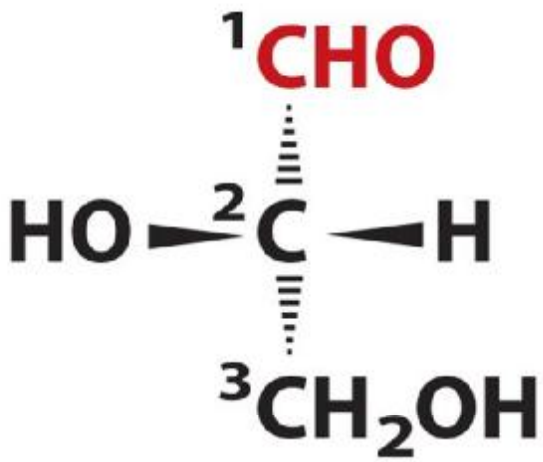
D-Alanine



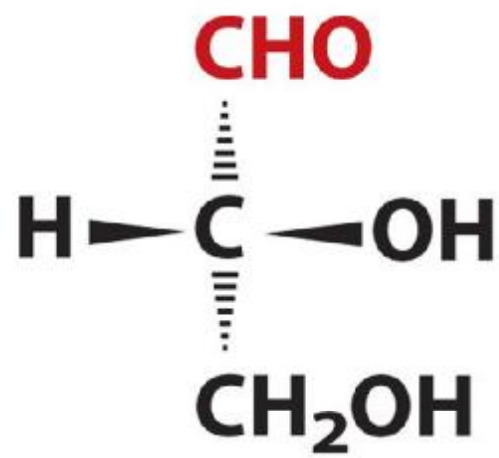
L-Alanine



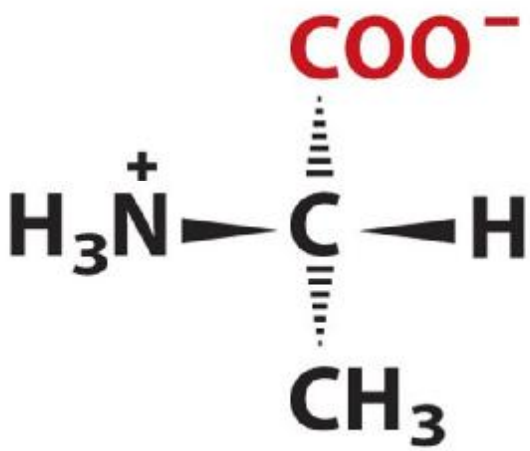
D-Alanine



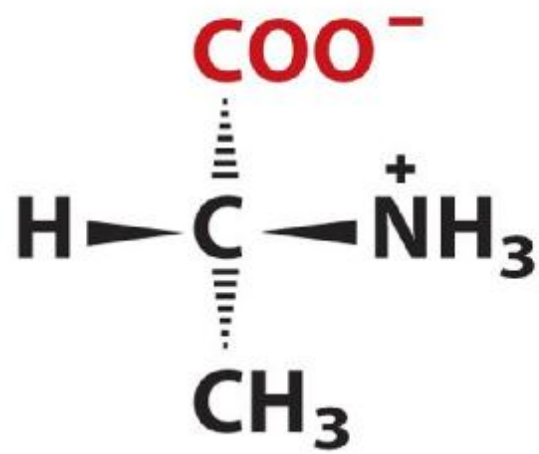
L-Glyceraldehyde



D-Glyceraldehyde



L-Alanine



D-Alanine

TABLE 3–1 Properties and Conventions Associated with the Common Amino Acids Found in Proteins

Amino acid	Abbreviation/ symbol	M_r	pK_a values: pK_1 (—COOH)	pK_2 ($—NH_3^+$)	pK_R (R group)	pI	Hydropathy index*	Occurrence in proteins (%)†
Nonpolar, aliphatic R groups								
Glycine	Gly G	75	2.34	9.60		5.97	−0.4	7.2
Alanine	Ala A	89	2.34	9.69		6.01	1.8	7.8
Proline	Pro P	115	1.99	10.96		6.48	1.6	5.2
Valine	Val V	117	2.32	9.62		5.97	4.2	6.6
Leucine	Leu L	131	2.36	9.60		5.98	3.8	9.1
Isoleucine	Ile I	131	2.36	9.68		6.02	4.5	5.3
Methionine	Met M	149	2.28	9.21		5.74	1.9	2.3
Aromatic R groups								
Phenylalanine	Phe F	165	1.83	9.13		5.48	2.8	3.9
Tyrosine	Tyr Y	181	2.20	9.11	10.07	5.66	−1.3	3.2
Tryptophan	Trp W	204	2.38	9.39		5.89	−0.9	1.4

*A scale combining hydrophobicity and hydrophilicity of R groups; it can be used to measure the tendency of an amino acid to seek an aqueous environment (− values) or a hydrophobic environment (+ values). See Chapter 11. From Kyte, J. & Doolittle, R.F. (1982) A simple method for displaying the hydropathic character of a protein. *J. Mol. Biol.* **157**, 105–132.

†Average occurrence in more than 1,150 proteins. From Doolittle, R.F. (1989) Redundancies in protein sequences. In *Prediction of Protein Structure and the Principles of Protein Conformation* (Fasman, G.D., ed.), pp. 599–623, Plenum Press, New York.

TABLE 3–1 Properties and Conventions Associated with the Common Amino Acids Found in Proteins

Amino acid	Abbreviation/ symbol	M_r	pK_a values: pK_1 (—COOH)	pK_2 ($—NH_3^+$)	pK_R (R group)	pI	Hydropathy index*	Occurrence in proteins (%)†
Polar, uncharged R groups								
Serine	Ser S	105	2.21	9.15		5.68	−0.8	6.8
Threonine	Thr T	119	2.11	9.62		5.87	−0.7	5.9
Cysteine	Cys C	121	1.96	10.28	8.18	5.07	2.5	1.9
Asparagine	Asn N	132	2.02	8.80		5.41	−3.5	4.3
Glutamine	Gln Q	146	2.17	9.13		5.65	−3.5	4.2
Positively charged R groups								
Lysine	Lys K	146	2.18	8.95	10.53	9.74	−3.9	5.9
Histidine	His H	155	1.82	9.17	6.00	7.59	−3.2	2.3
Arginine	Arg R	174	2.17	9.04	12.48	10.76	−4.5	5.1
Negatively charged R groups								
Aspartate	Asp D	133	1.88	9.60	3.65	2.77	−3.5	5.3
Glutamate	Glu E	147	2.19	9.67	4.25	3.22	−3.5	6.3

*A scale combining hydrophobicity and hydrophilicity of R groups; it can be used to measure the tendency of an amino acid to seek an aqueous environment (− values) or a hydrophobic environment (+ values). See Chapter 11. From Kyte, J. & Doolittle, R.F. (1982) A simple method for displaying the hydropathic character of a protein. *J. Mol. Biol.* **157**, 105–132.

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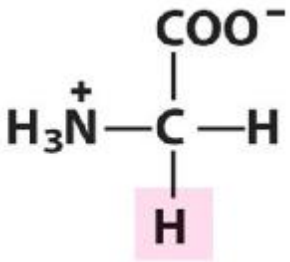
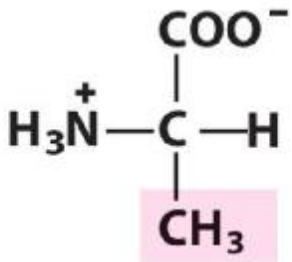
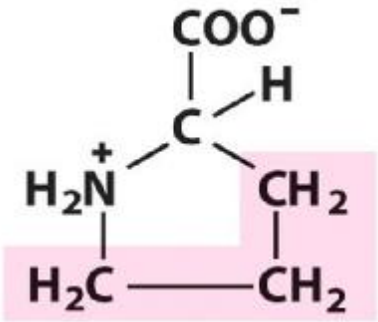
Nonpolar, aliphatic R groups



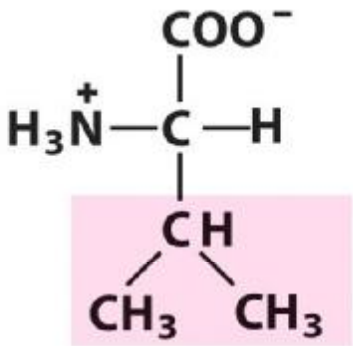
Glycine



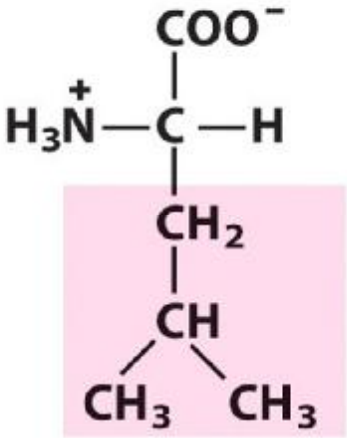
Alanine



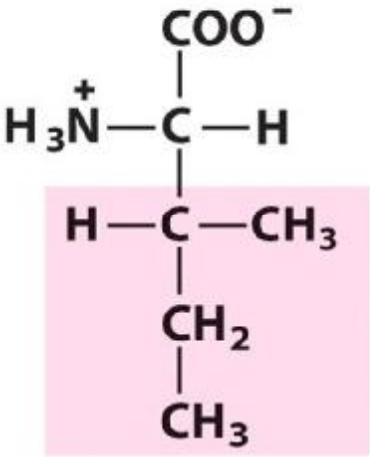
Proline



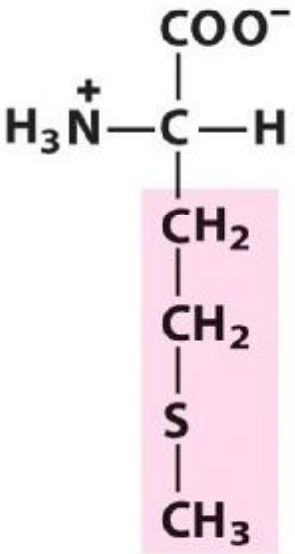
Valine



Leucine

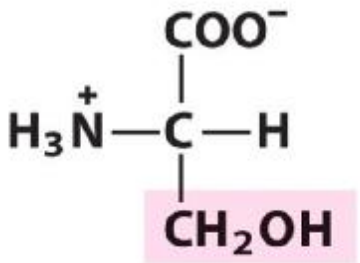


Isoleucine

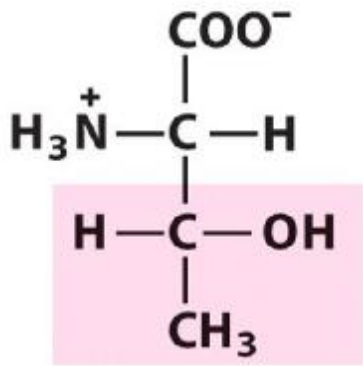


Methionine

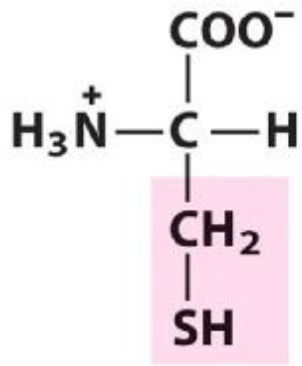
Polar, uncharged R groups



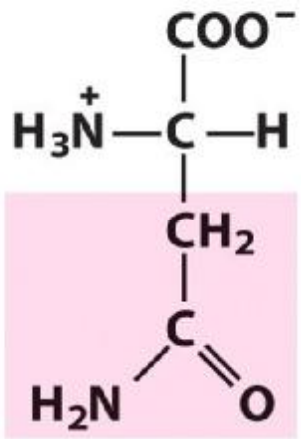
Serine



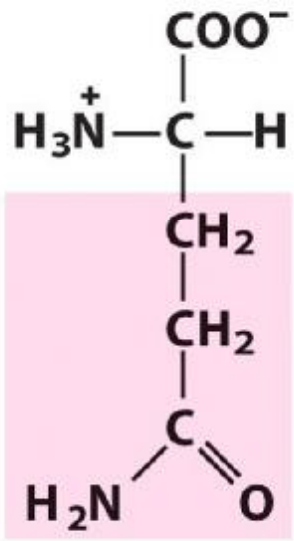
Threonine



Cysteine

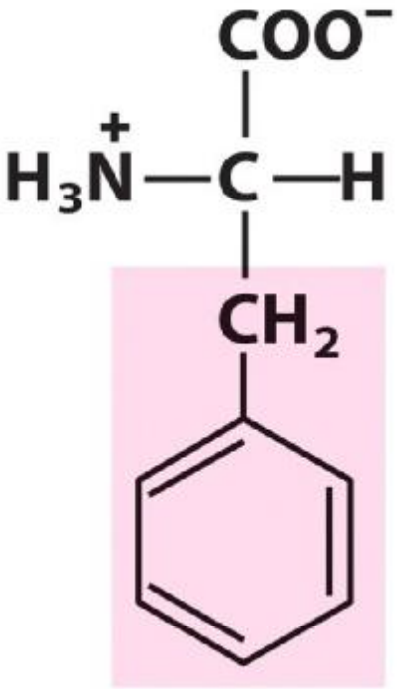


Asparagine

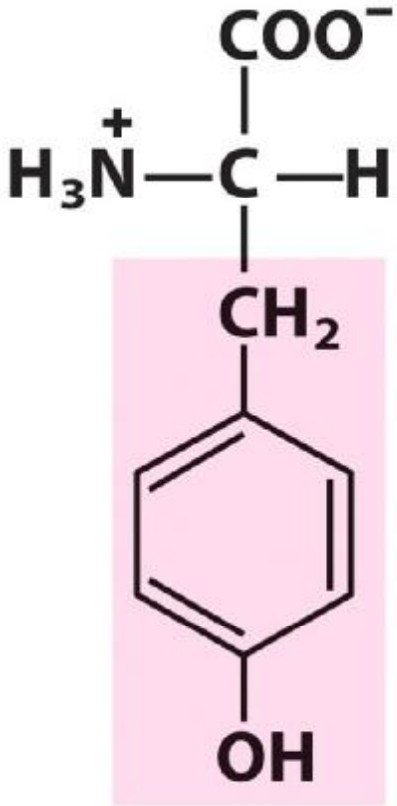


Glutamine

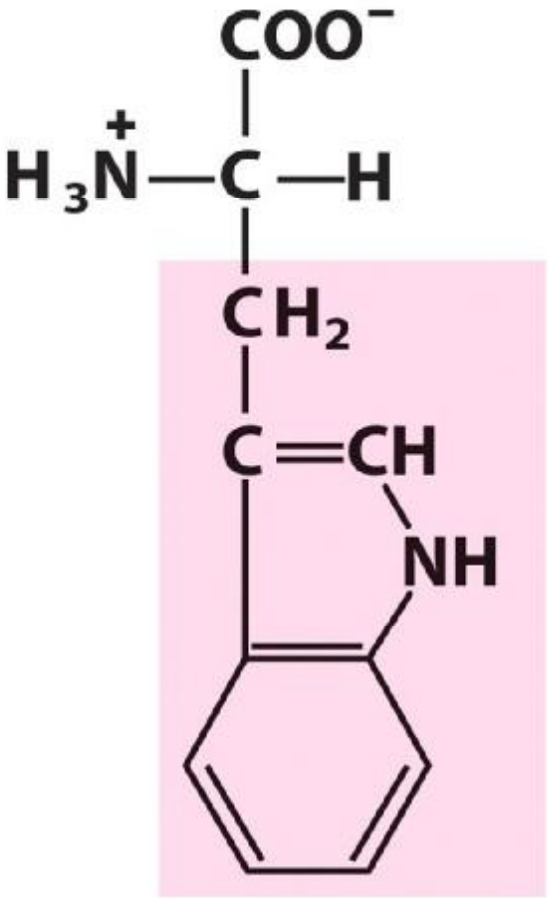
Aromatic R groups



Phenylalanine

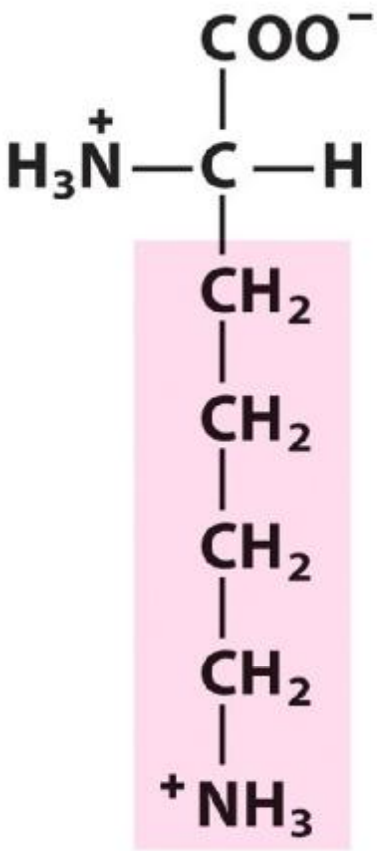


Tyrosine

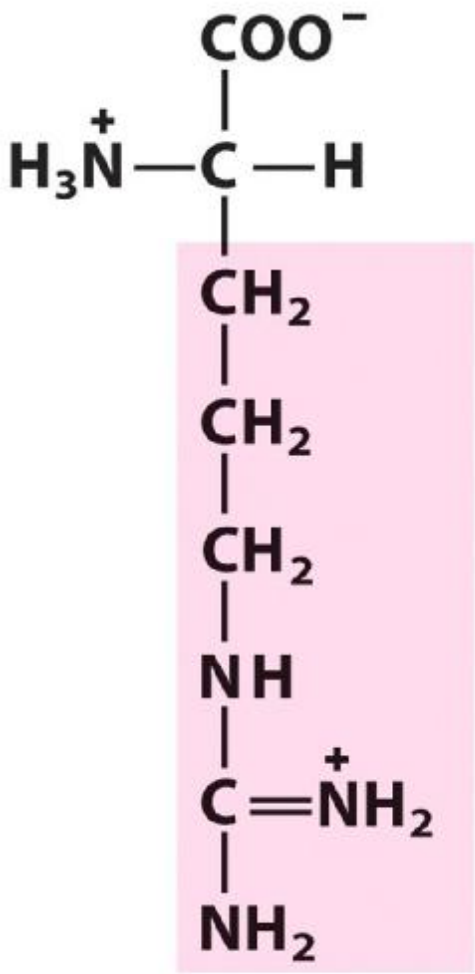


Tryptophan

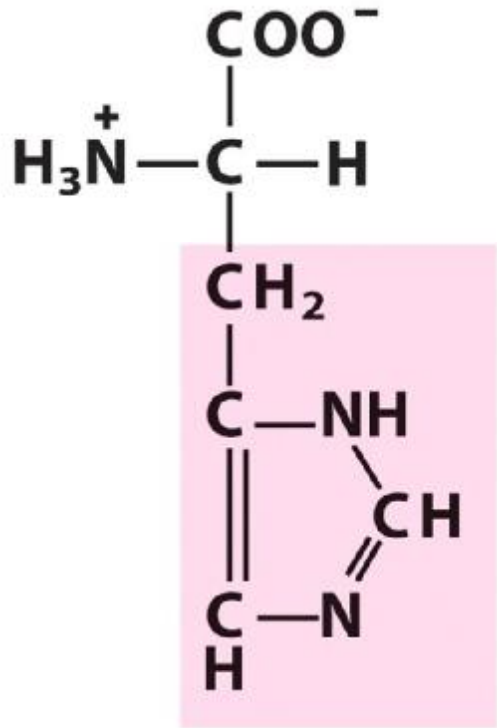
Positively charged R groups



Lysine

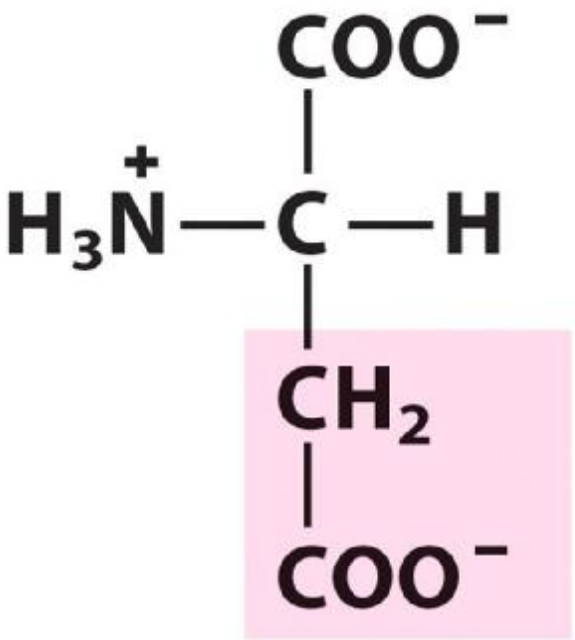


Arginine

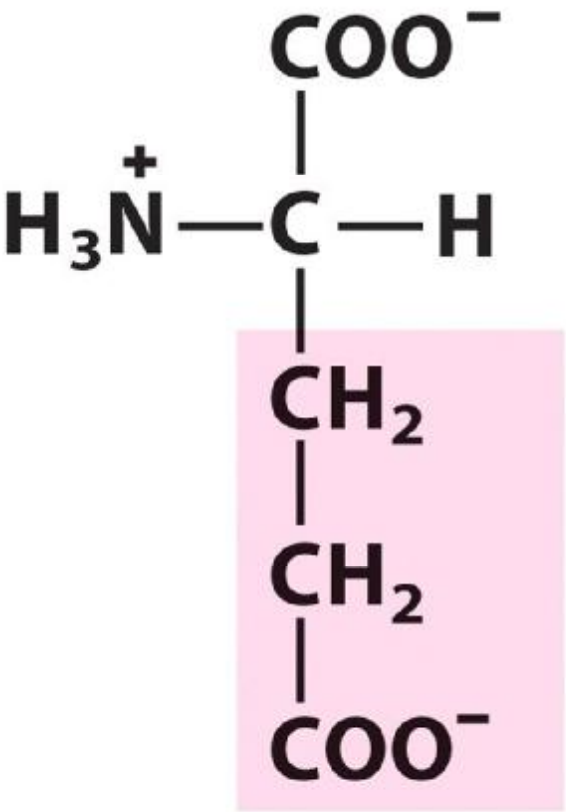


Histidine

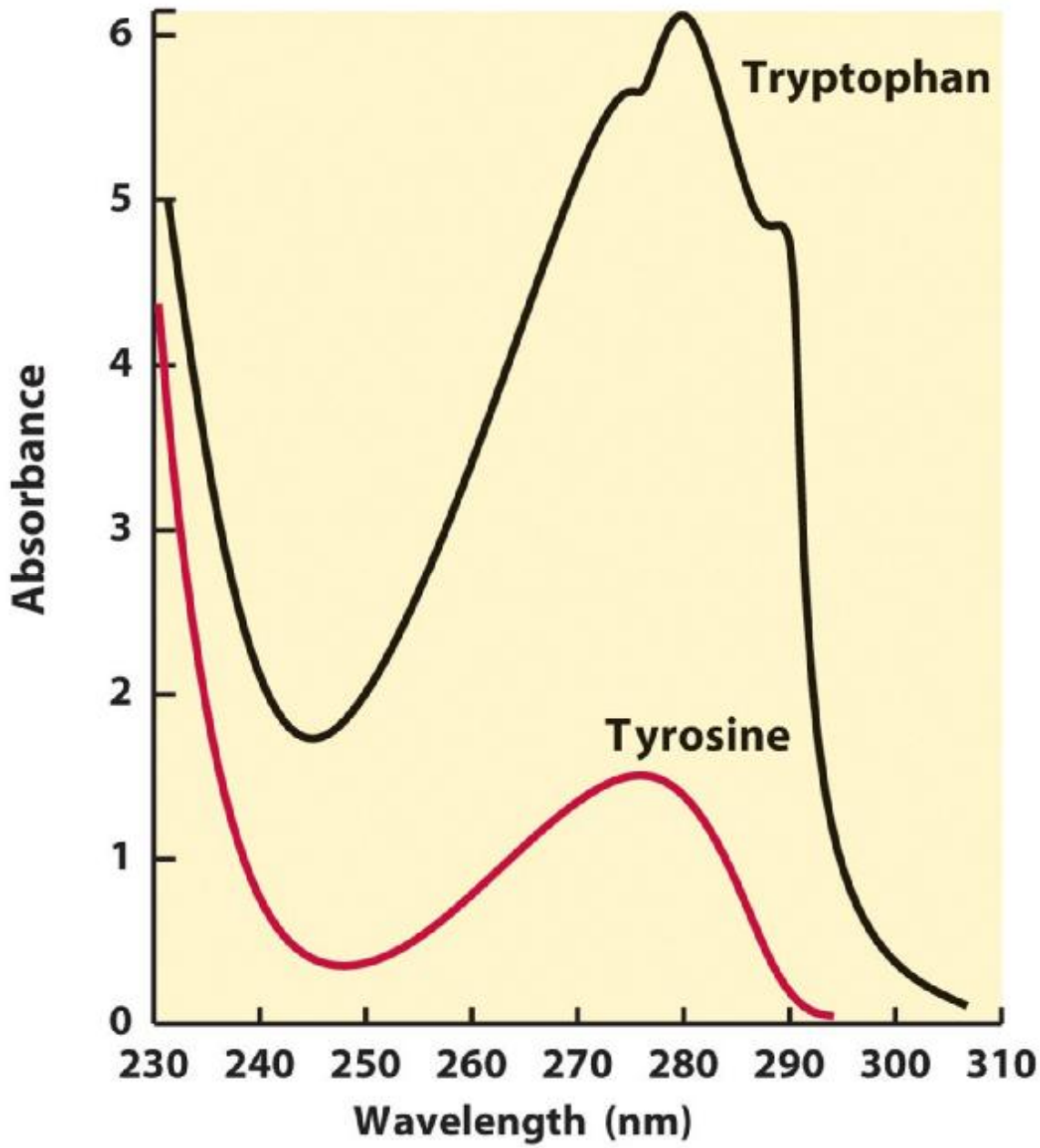
Negatively charged R groups

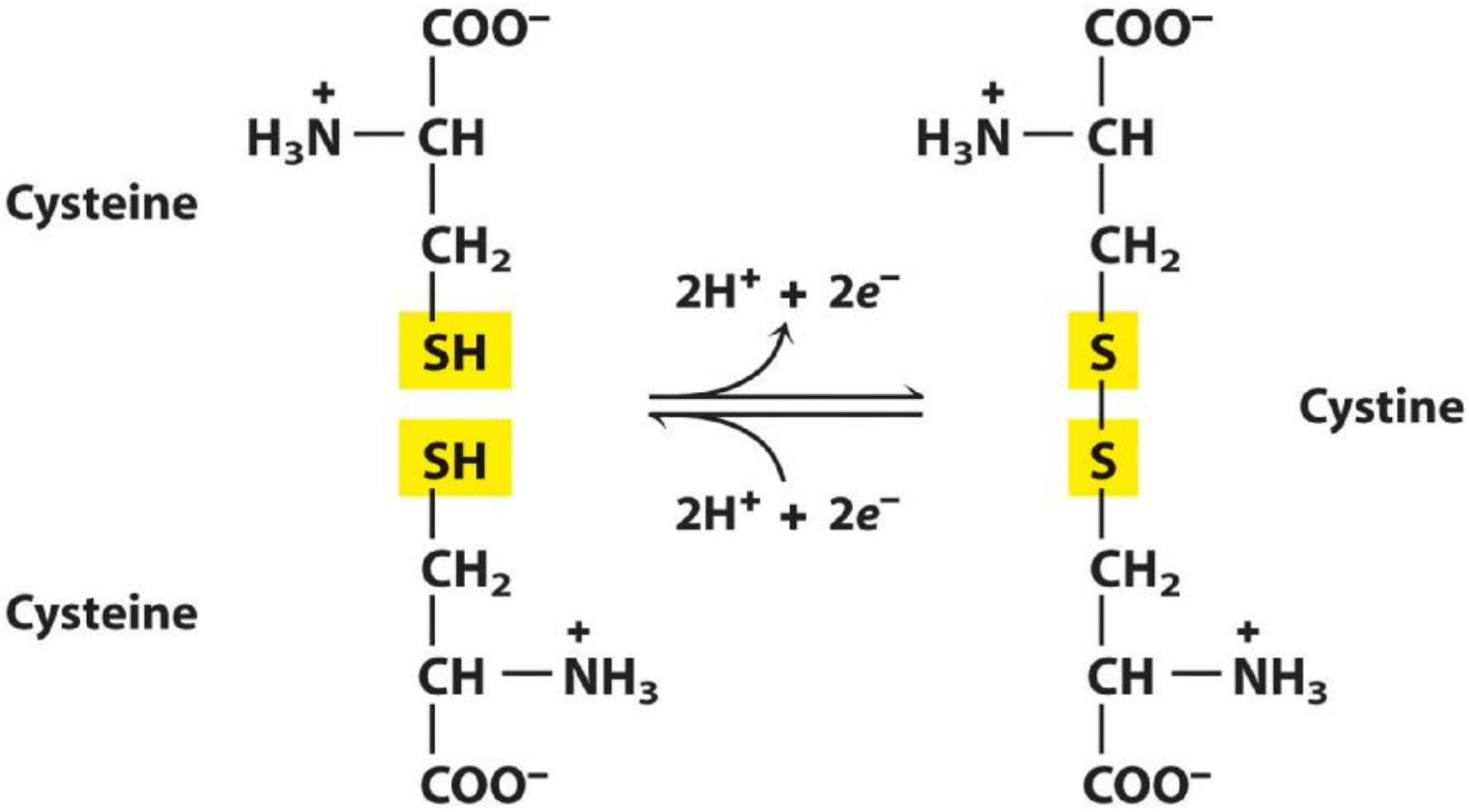


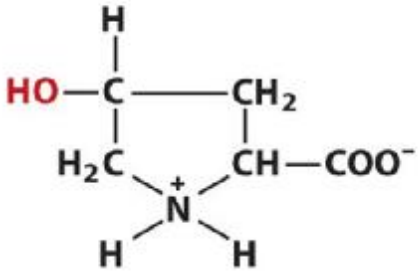
Aspartate



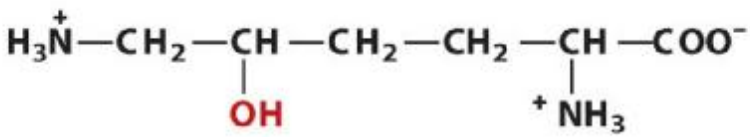
Glutamate


Tryptophan
Tyrosine
Absorbance
0
1
2
3
4
5
6
230
240
250
260
270
280
290
300
310
Wavelength (nm)

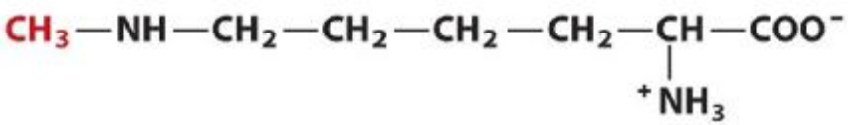

Cysteine
Cysteine
Cystine
COO⁻
H₃N⁺ — CH
CH₂
SH
SH
CH₂
CH — NH₃⁺
COO⁻
2H⁺ + 2e⁻
2H⁺ + 2e⁻
COO⁻
H₃N⁺ — CH
CH₂
S
S
CH₂
CH — NH₃⁺
COO⁻



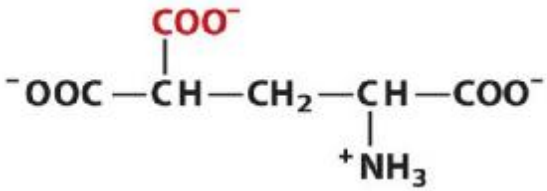
4-Hydroxyproline



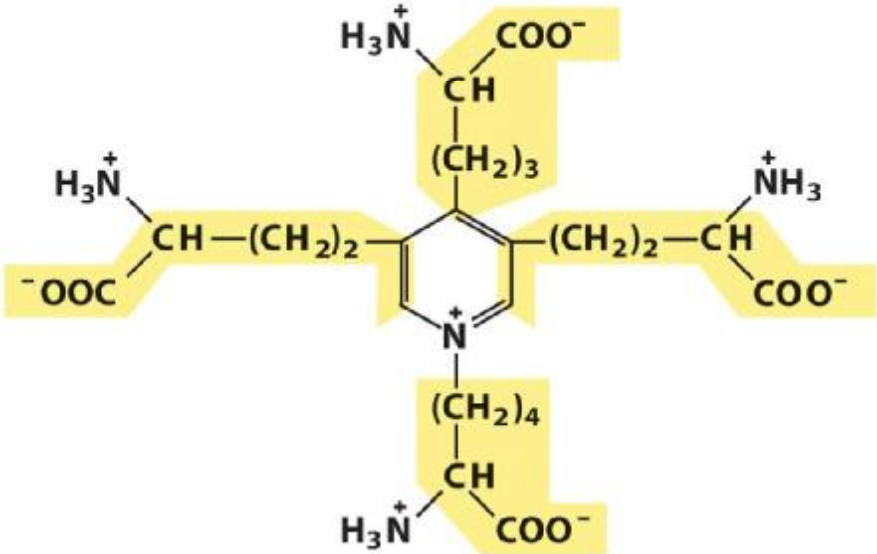
5-Hydroxylysine



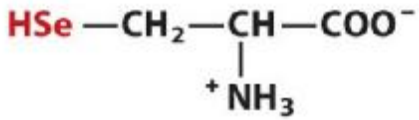
6-*N*-Methyllysine



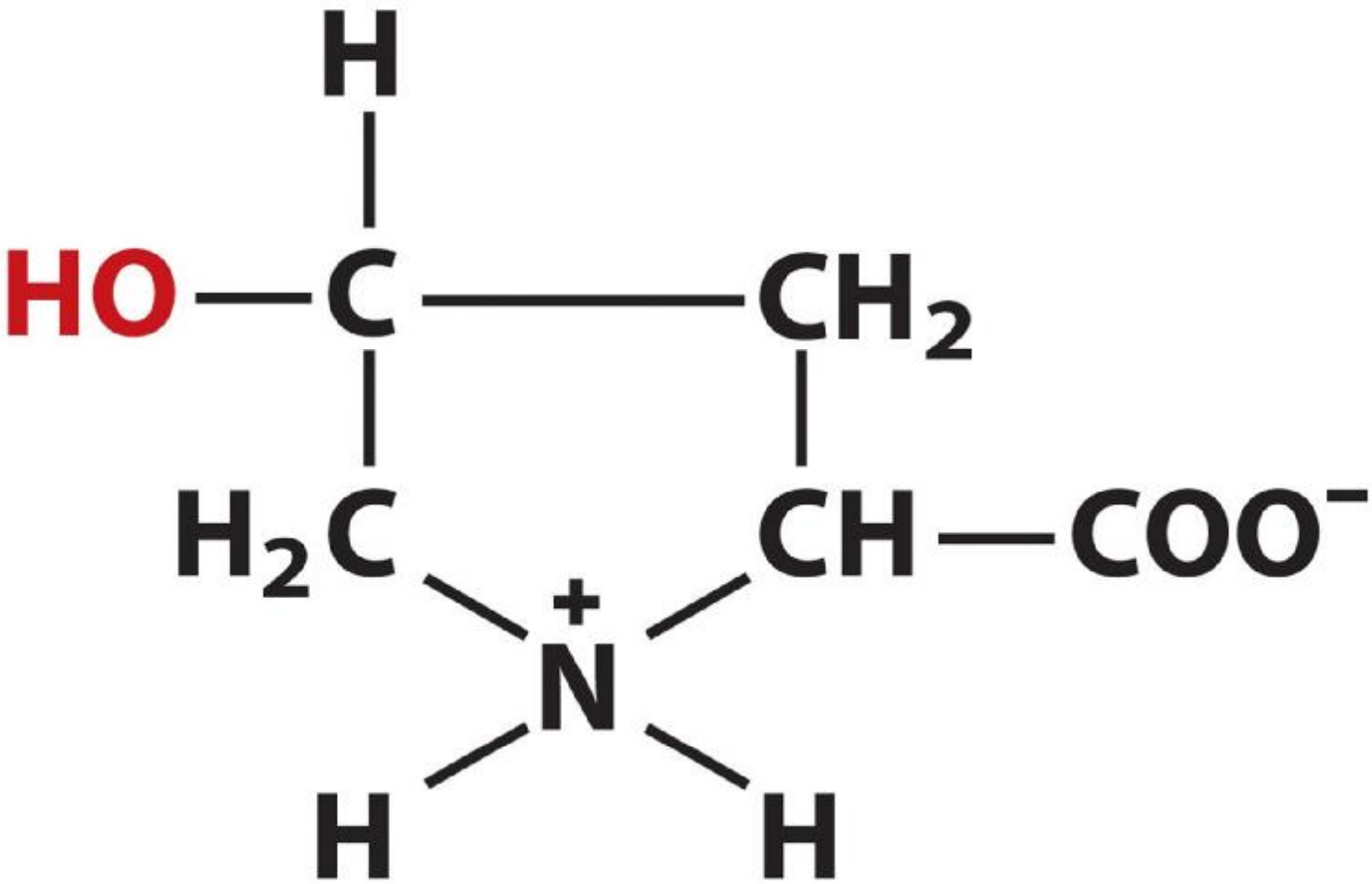
γ-Carboxyglutamate



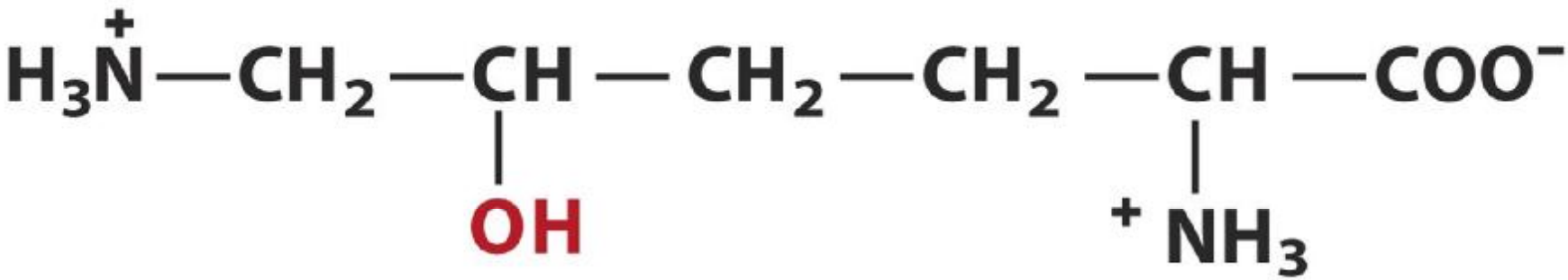
Desmosine



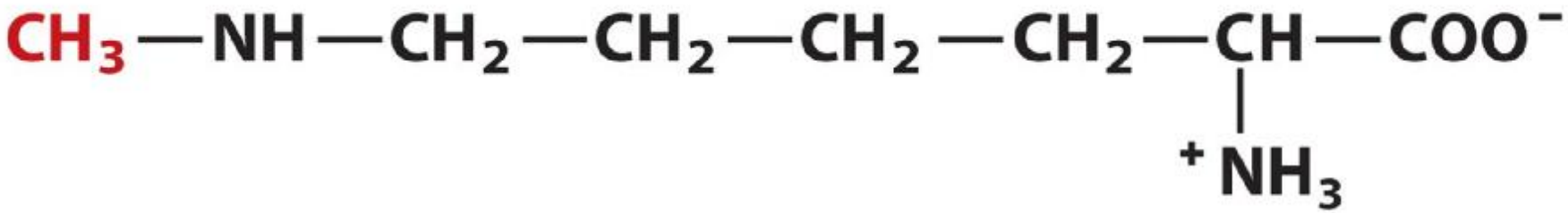
Selenocysteine



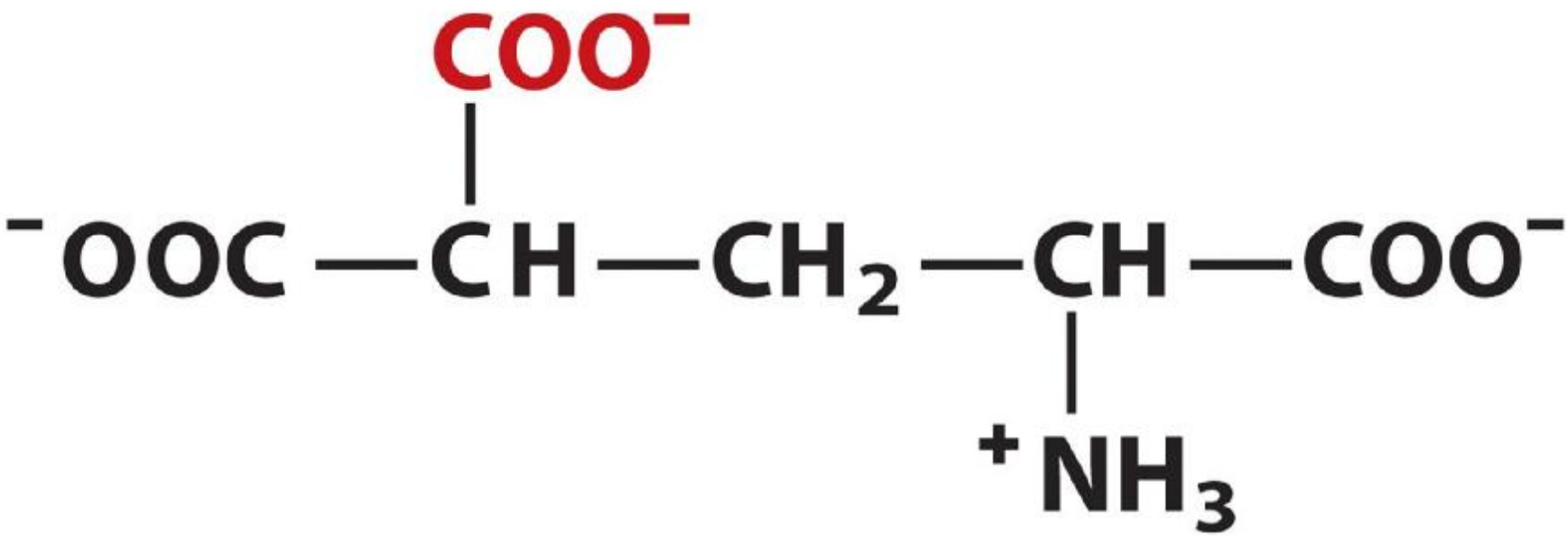
4-Hydroxyproline



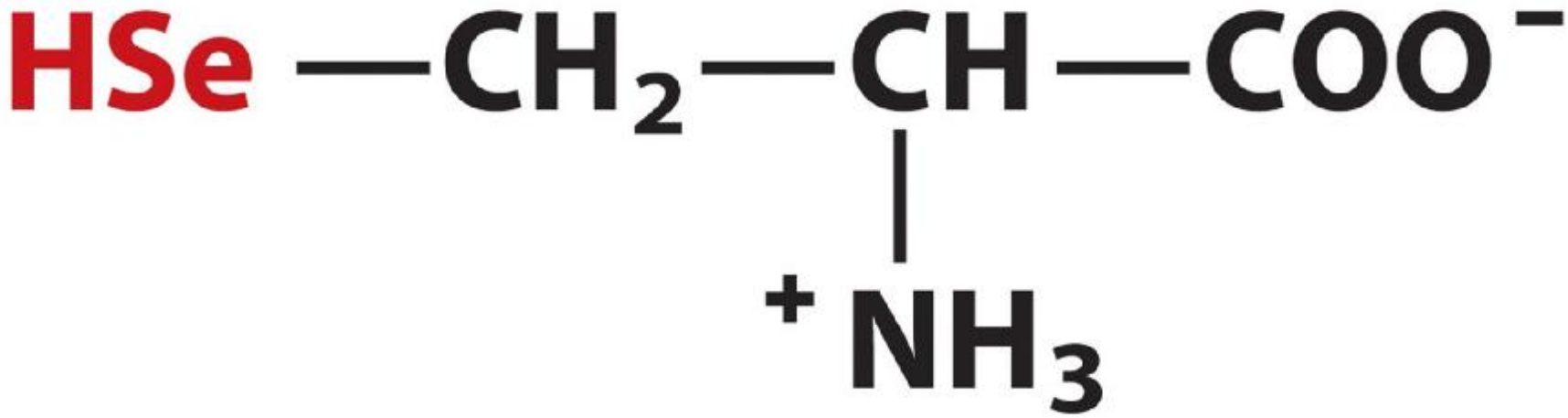
5-Hydroxylysine



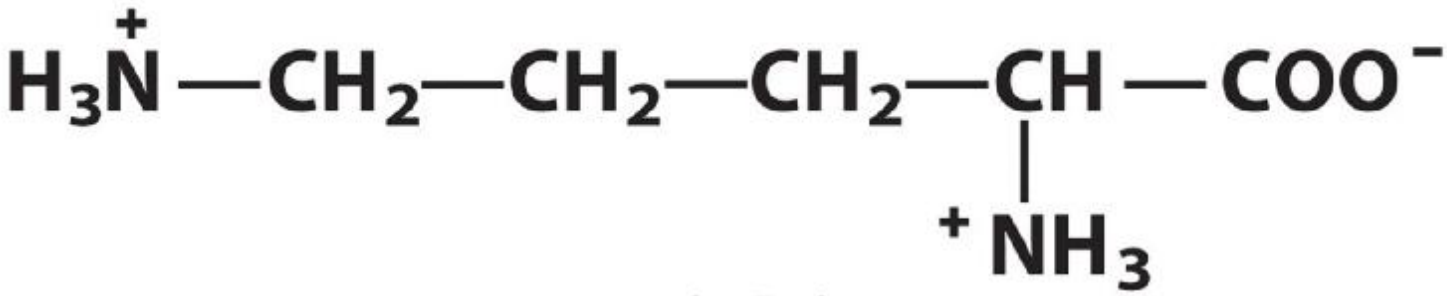
6-*N*-Methyllysine



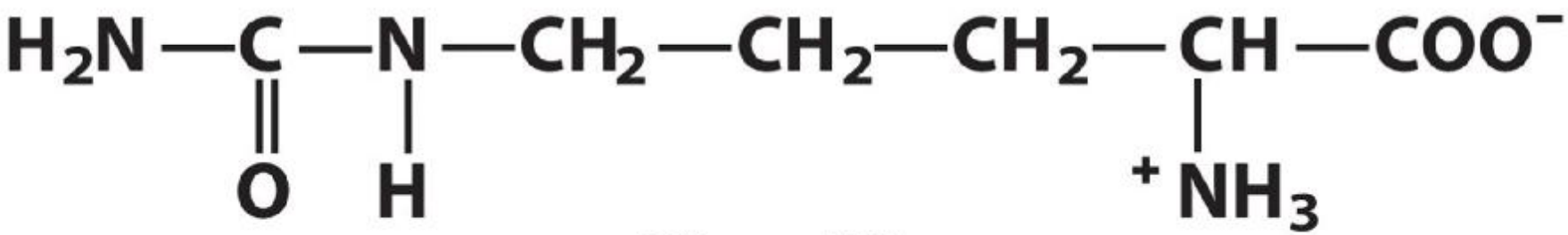
γ-Carboxyglutamate



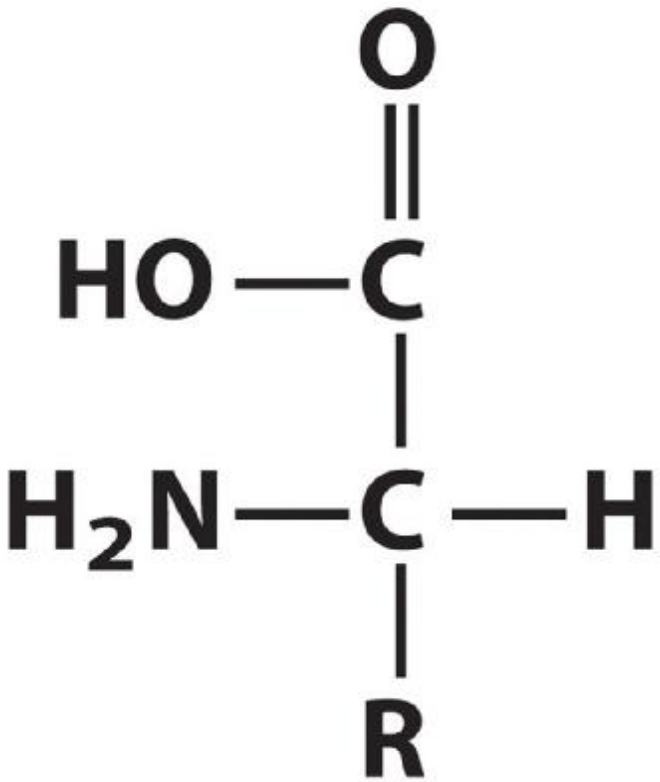
Selenocysteine



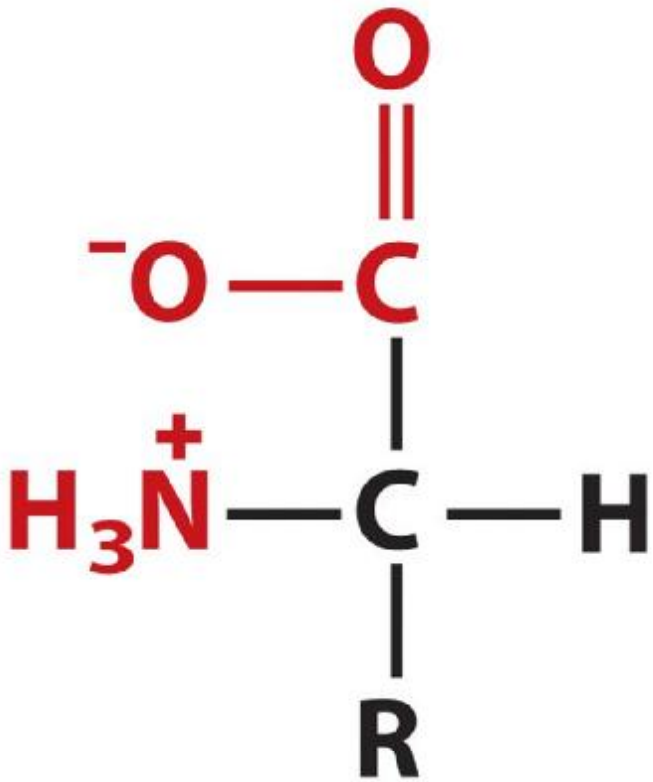
Ornithine



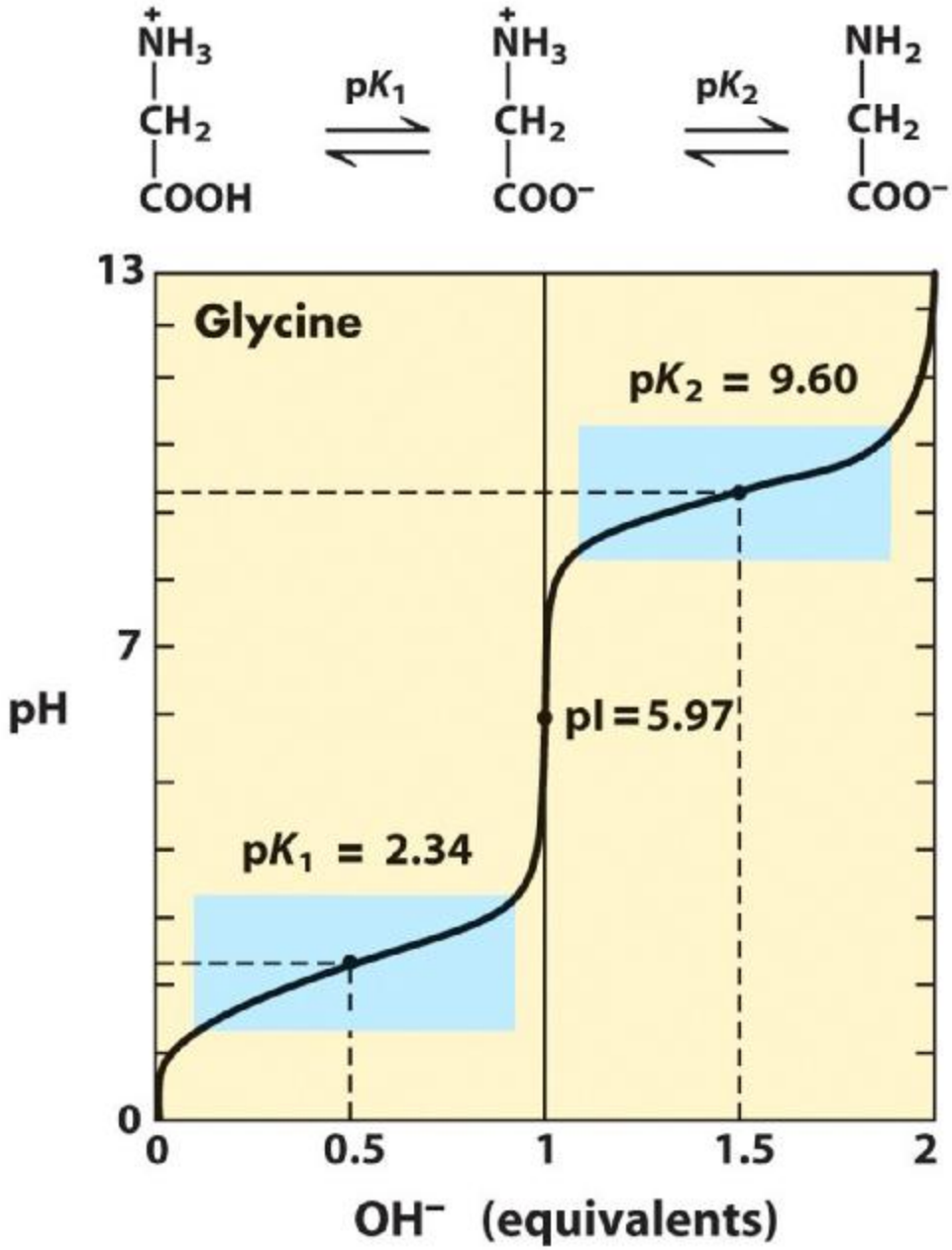
Citrulline

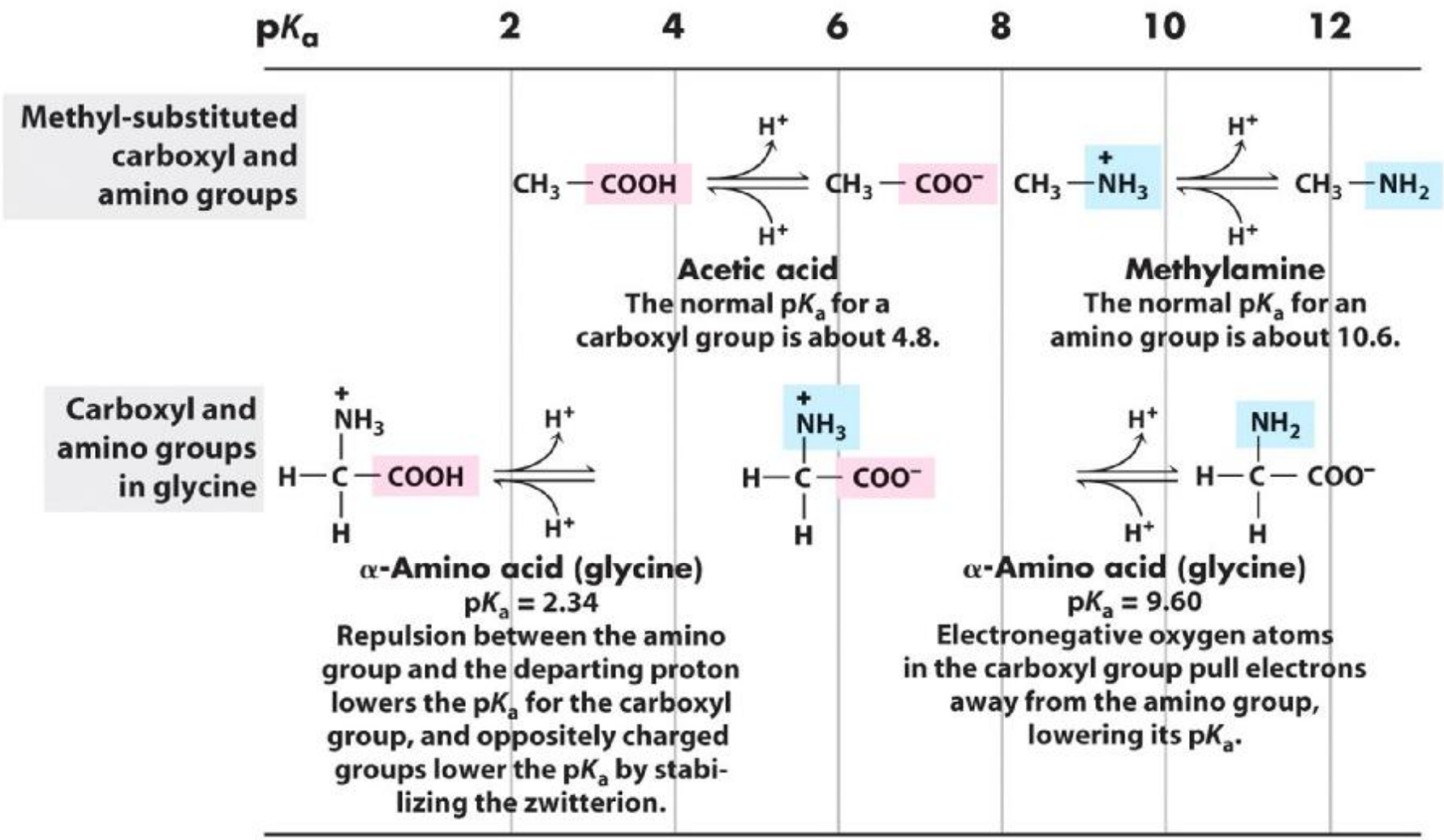


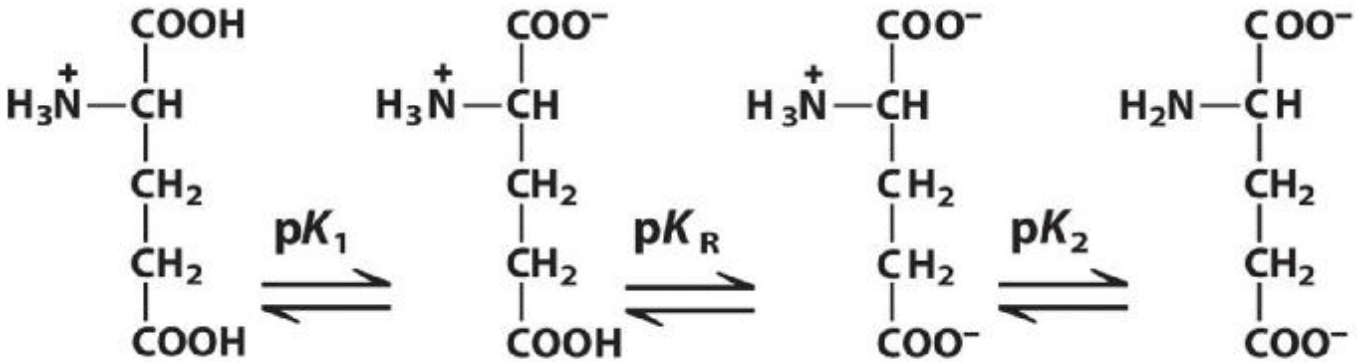
Nonionic form

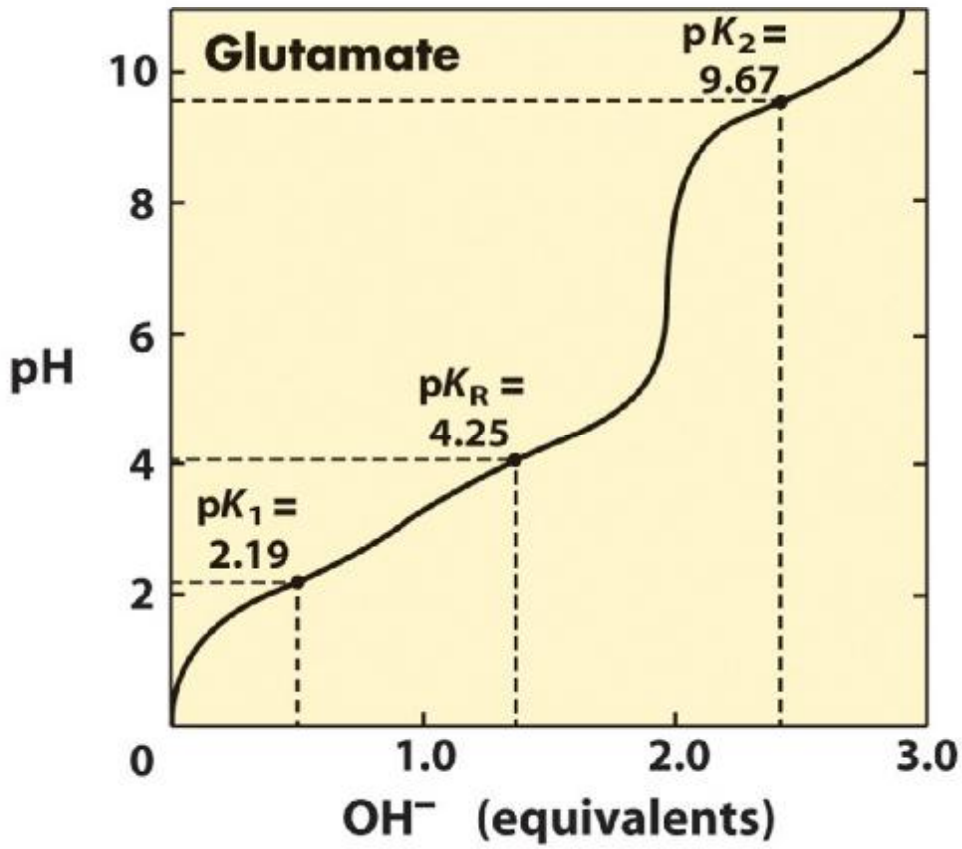


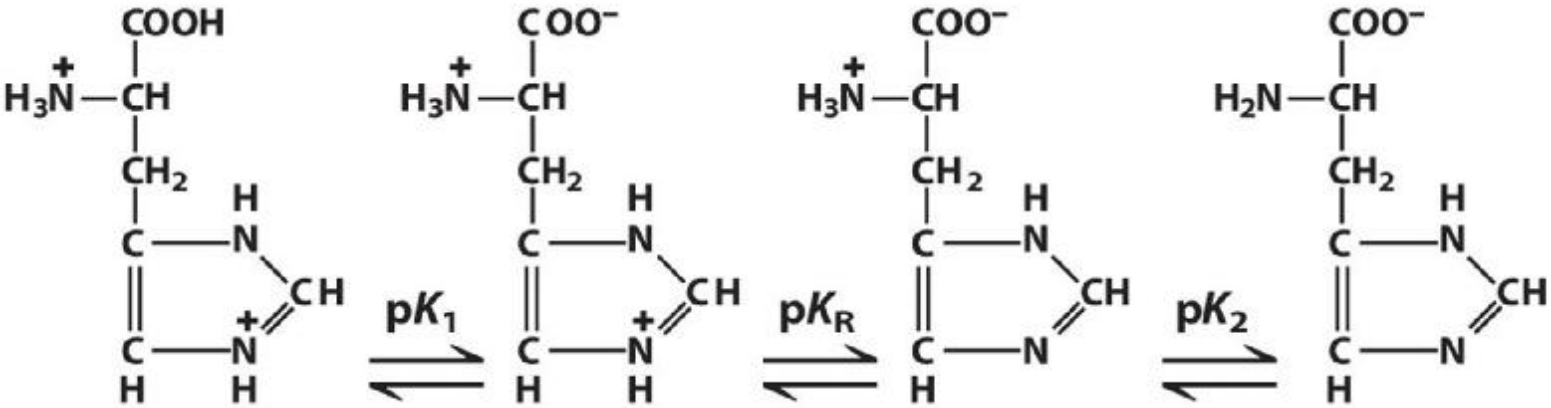
Zwitterionic form

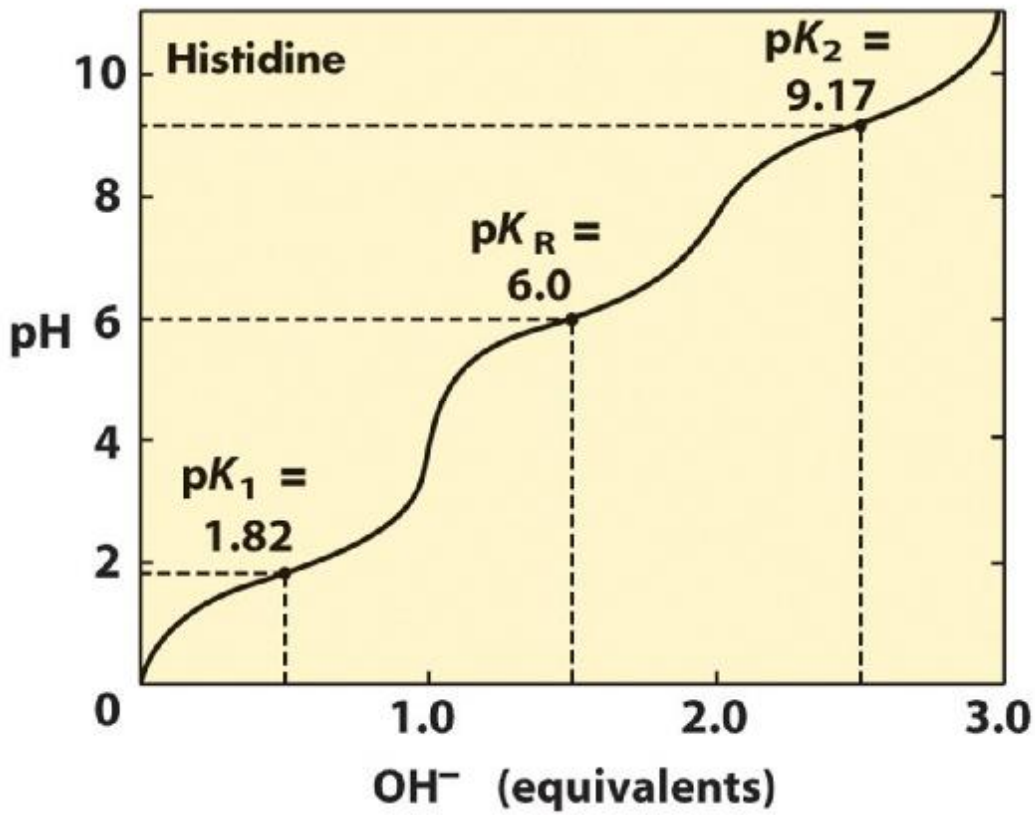

NH3
CH2
COOH
pK1
NH3
CH2
COO−
pK2
NH2
CH2
COO−
Glycine
pK2 = 9.60
pI = 5.97
pK1 = 2.34
pH
13
7
0
0
0.5
1
1.5
2
OH− (equivalents)


pKa
2
4
6
8
10
12
Methyl-substituted carboxyl and amino groups
CH3—COOH
H+
CH3—COO−
H+
Acetic acid
The normal pKa for a carboxyl group is about 4.8.
CH3—NH3+
H+
CH3—NH2
H+
Methylamine
The normal pKa for an amino group is about 10.6.
Carboxyl and amino groups in glycine
NH3+
H—C—COOH
H
H+
H+
NH3+
H—C—COO−
H
α-Amino acid (glycine)
pKa = 2.34
Repulsion between the amino group and the departing proton lowers the pKa for the carboxyl group, and oppositely charged groups lower the pKa by stabilizing the zwitterion.
H+
H+
NH2
H—C—COO−
H
α-Amino acid (glycine)
pKa = 9.60
Electronegative oxygen atoms in the carboxyl group pull electrons away from the amino group, lowering its pKa.


COOH
H3N—CH
CH2
CH2
COOH
pK1
COO⁻
H3N—CH
CH2
CH2
COOH
pKR
COO⁻
H3N—CH
CH2
CH2
COO⁻
pK2
COO⁻
H2N—CH
CH2
CH2
COO⁻


Glutamate
pK2 = 9.67
pKR = 4.25
pK1 = 2.19
pH
10
8
6
4
2
0
1.0
2.0
3.0
OH⁻ (equivalents)


COOH
COO⁻
H₃N⁺—CH
H₂N—CH
CH₂
pK₁
pK_R
pK₂


Histidine
pK₂ = 9.17
pK_R = 6.0
pK₁ = 1.82
pH
0
2
4
6
8
10
1.0
2.0
3.0
OH⁻ (equivalents)