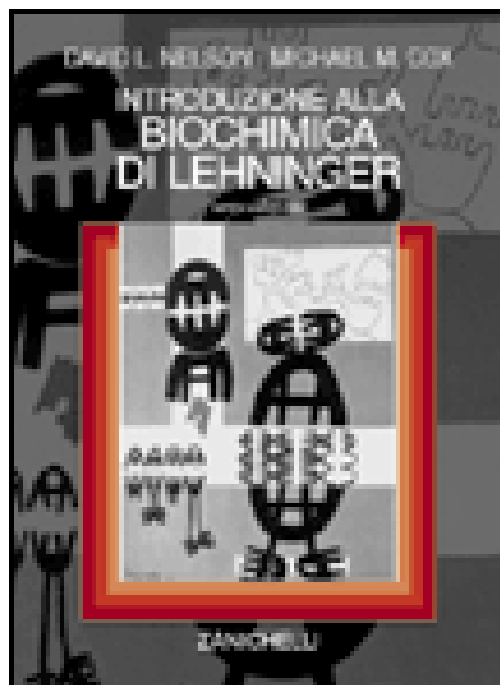
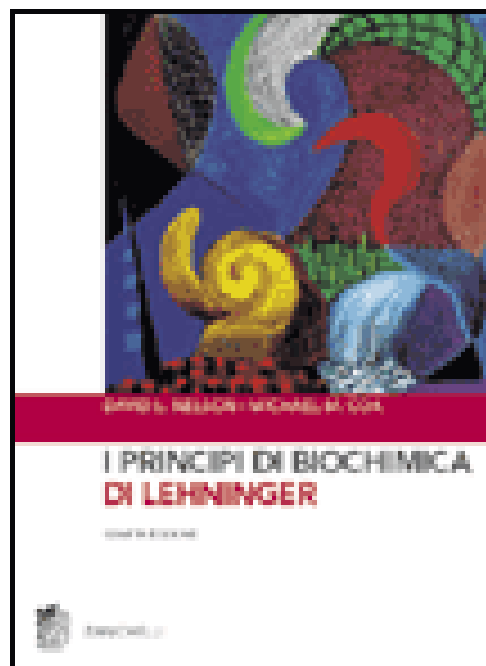




51,3 E



135 E



85,5 E

Ambiti di interesse della Biochimica

- Analisi delle proprietà chimiche e spaziali delle molecole biologiche
- Analisi delle interazioni tra le molecole biologiche
- Processi di degradazione e sintesi delle molecole biologiche
- Meccanismi di conservazione ed utilizzo dell'energia
- Meccanismi di organizzazione e coordinamento delle attività delle molecole biologiche
- Conservazione, trasmissione ed espressione dell'informazione genetica

1 H																	2 He		
3 Li	4 Be													5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg													13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra																		

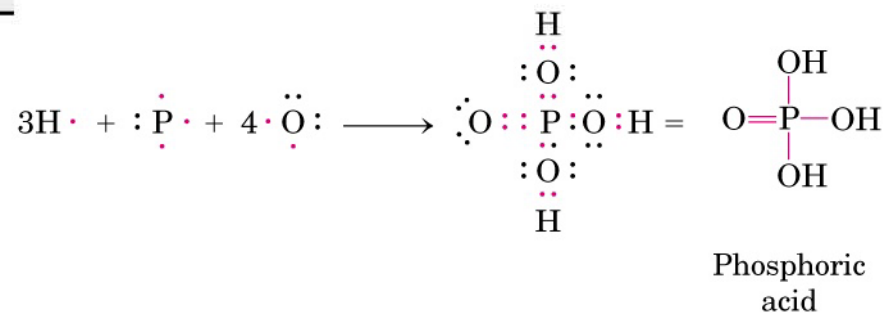
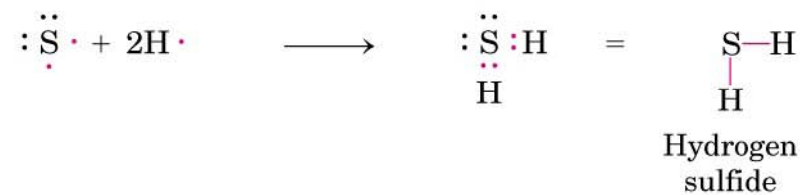
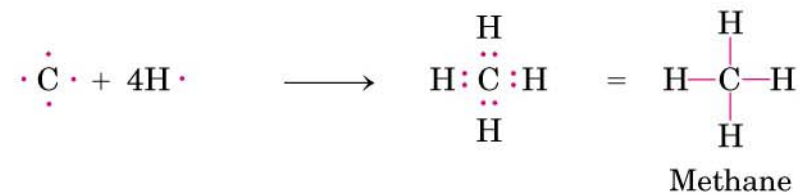
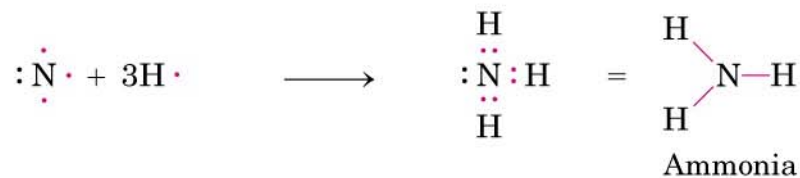
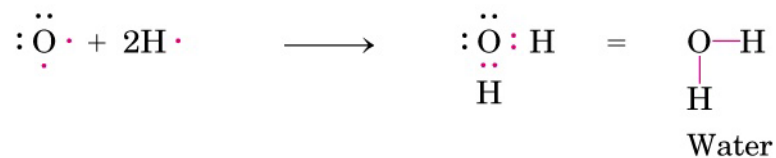
Bulk elements

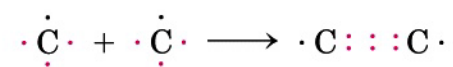
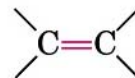
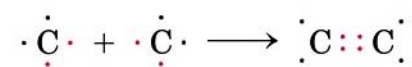
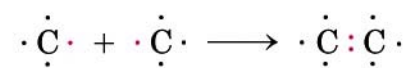
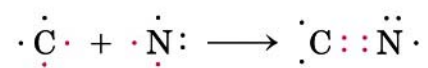
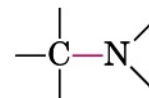
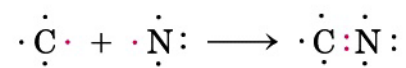
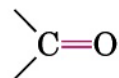
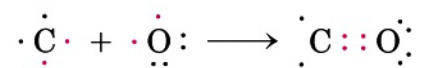
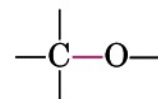
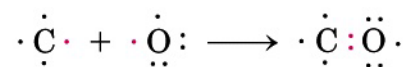
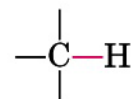
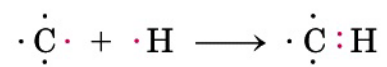
Trace elements

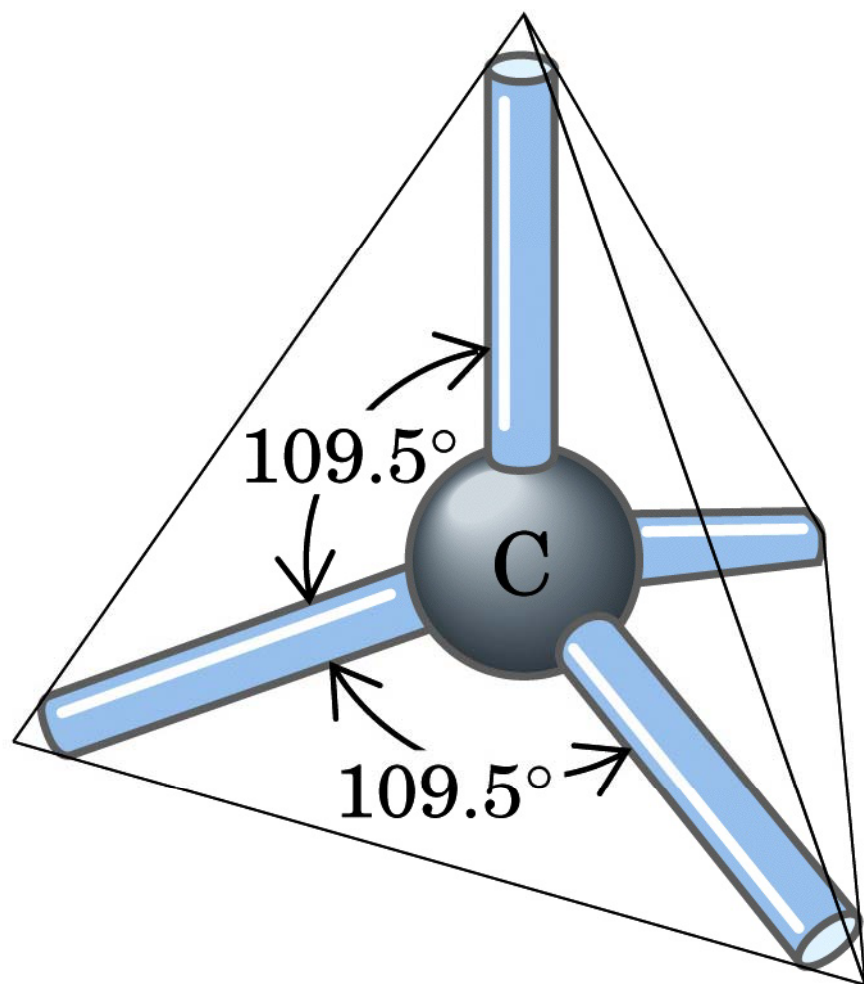
Lanthanides

Actinides

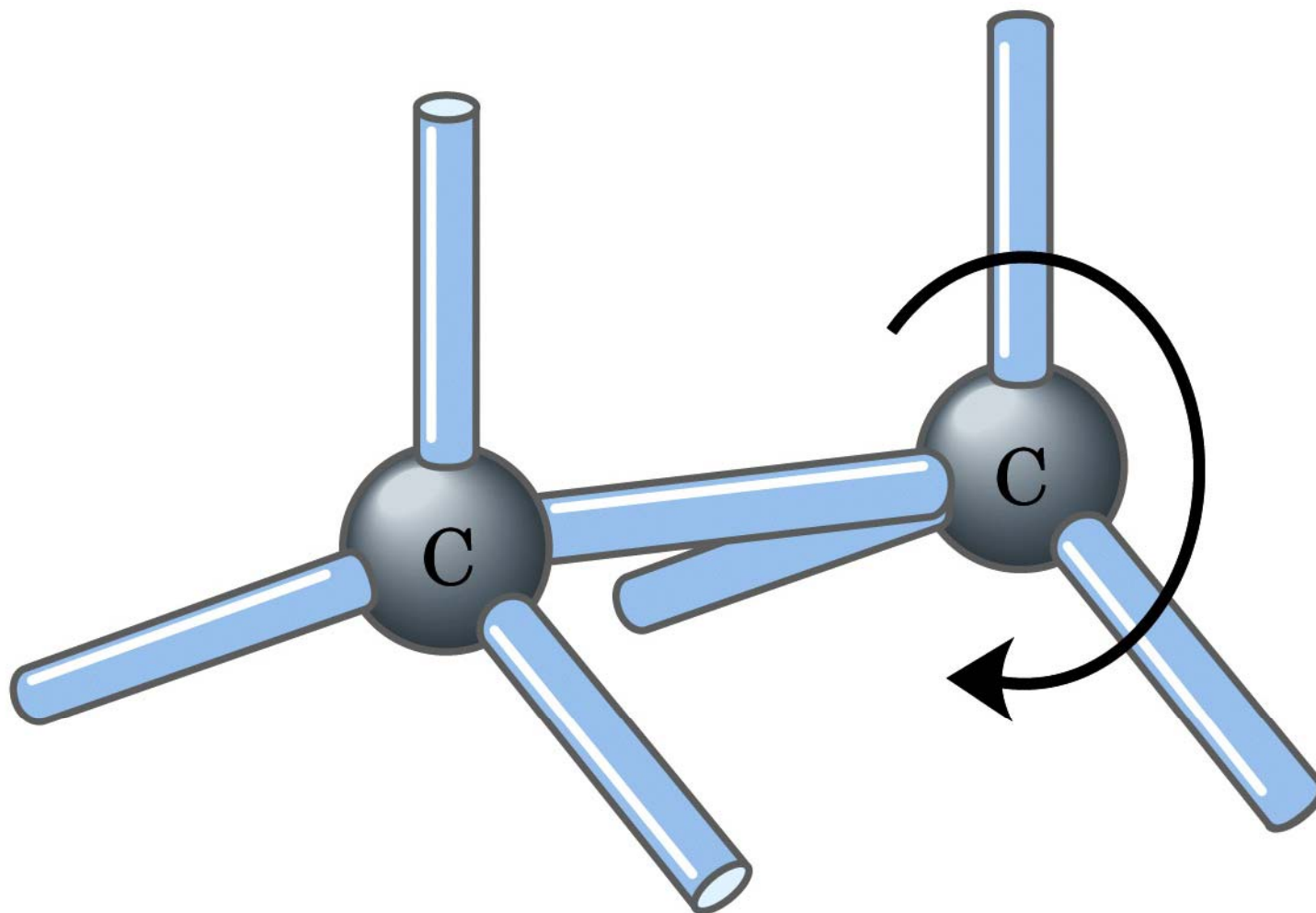
Atom	Number of unpaired electrons (in red)	Number of electrons in complete outer shell
H ·	1	2
· :O· :	2	8
· :N· :	3	8
· ·C· :	4	8
· :S· :	2	8
· :P· :	3	8



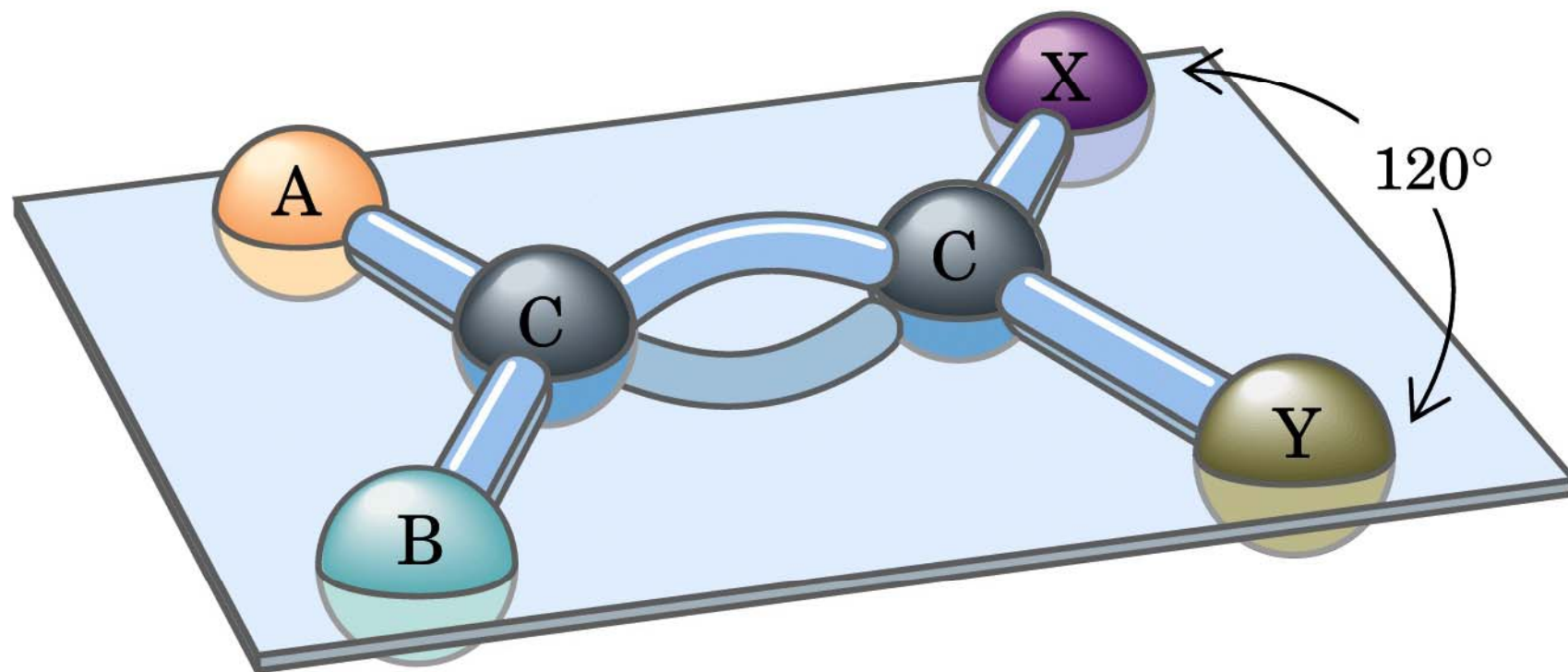




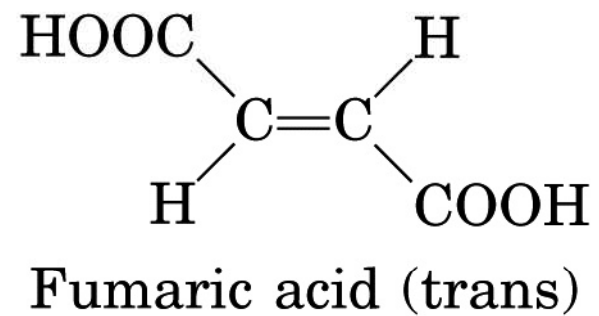
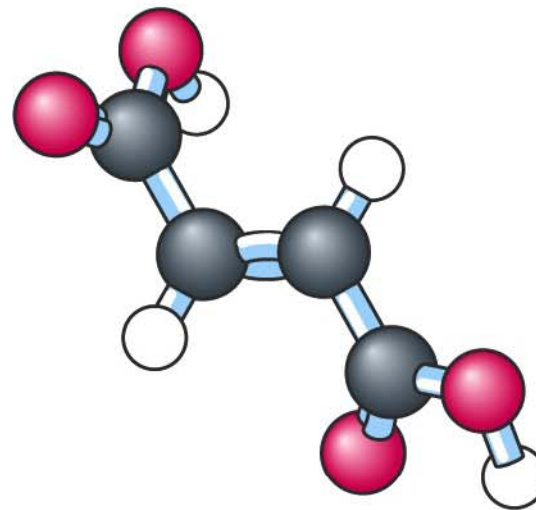
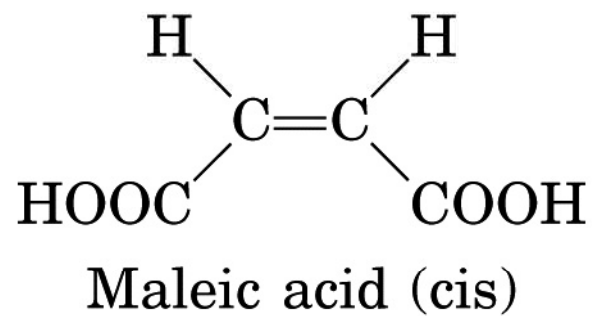
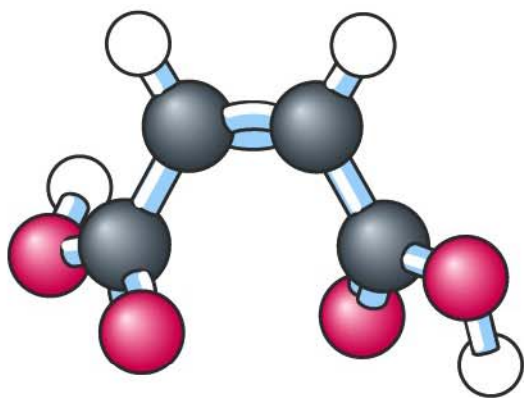
(a)



(b)



(c)



(a)

Le macromolecole sono i principali
costituenti delle cellule

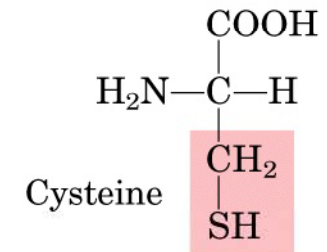
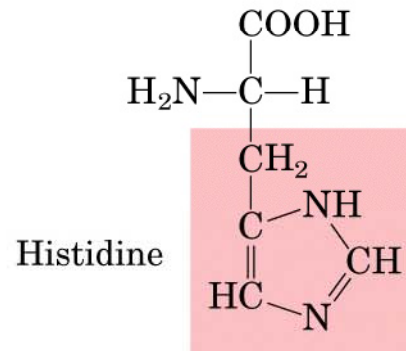
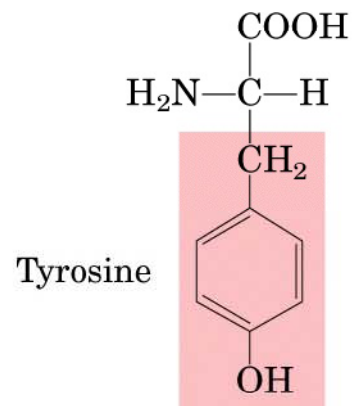
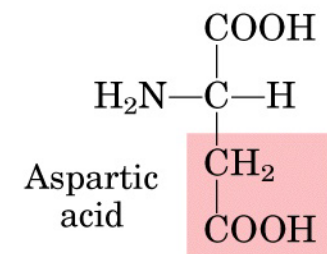
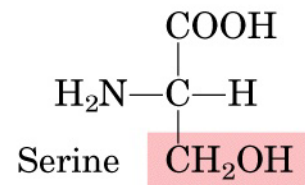
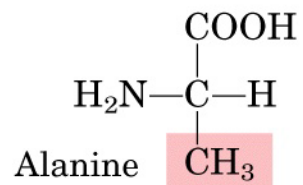
Le macromolecole sono costituite
da subunità monomeriche

table 3–5

Molecular Components of an *E. coli* Cell

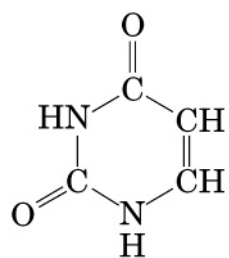
	Percentage of total weight of cell	Approximate number of different molecular species
Water	70	1
Proteins	15	3,000
Nucleic acids		
DNA	1	1
RNA	6	>3,000
Polysaccharides	3	5
Lipids	2	20
Monomeric subunits and intermediates	2	500
Inorganic ions	1	20

Some of the amino acids of proteins

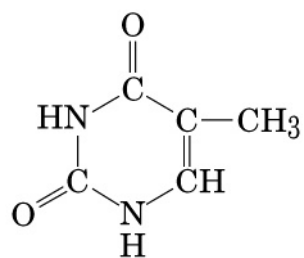


(a)

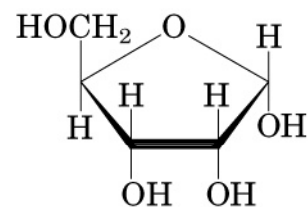
The components of nucleic acids



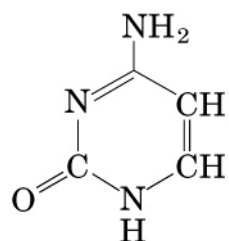
Uracil



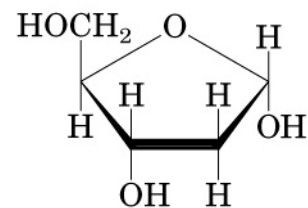
Thymine



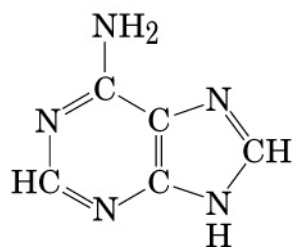
α -D-Ribose



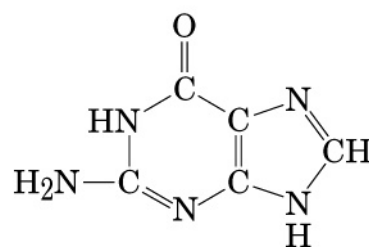
Cytosine



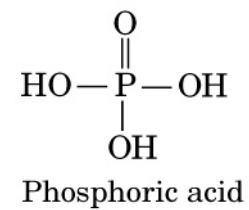
2-Deoxy- α -D-ribose



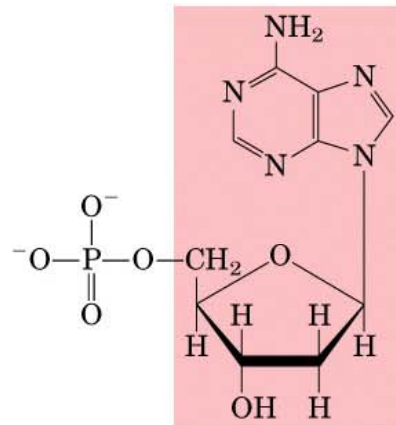
Adenine



Guanine



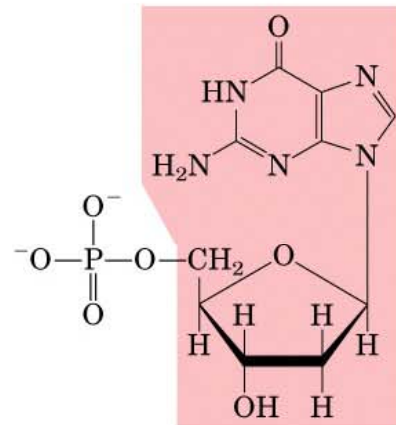
(b)



Nucleotide: Deoxyadenylate
(deoxyadenosine
5'-monophosphate)

Symbols: A, dA, dAMP

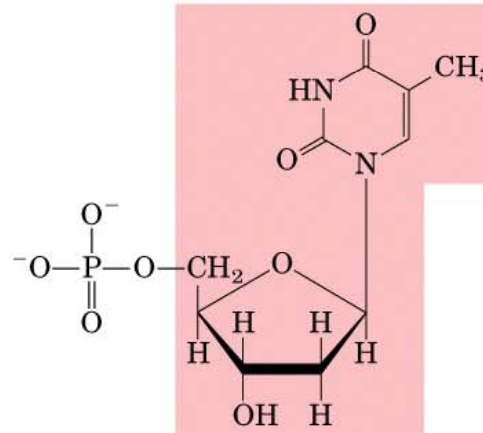
Nucleoside: Deoxyadenosine



Nucleotide: Deoxyguanylate
(deoxyguanosine
5'-monophosphate)

Symbols: G, dG, dGMP

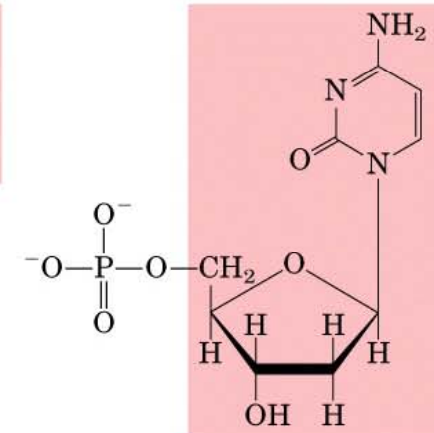
Nucleoside: Deoxyguanosine



Nucleotide: Deoxythymidylate
(deoxythymidine
5'-monophosphate)

Symbols: T, dT, dTMP

Nucleoside: Deoxythymidine

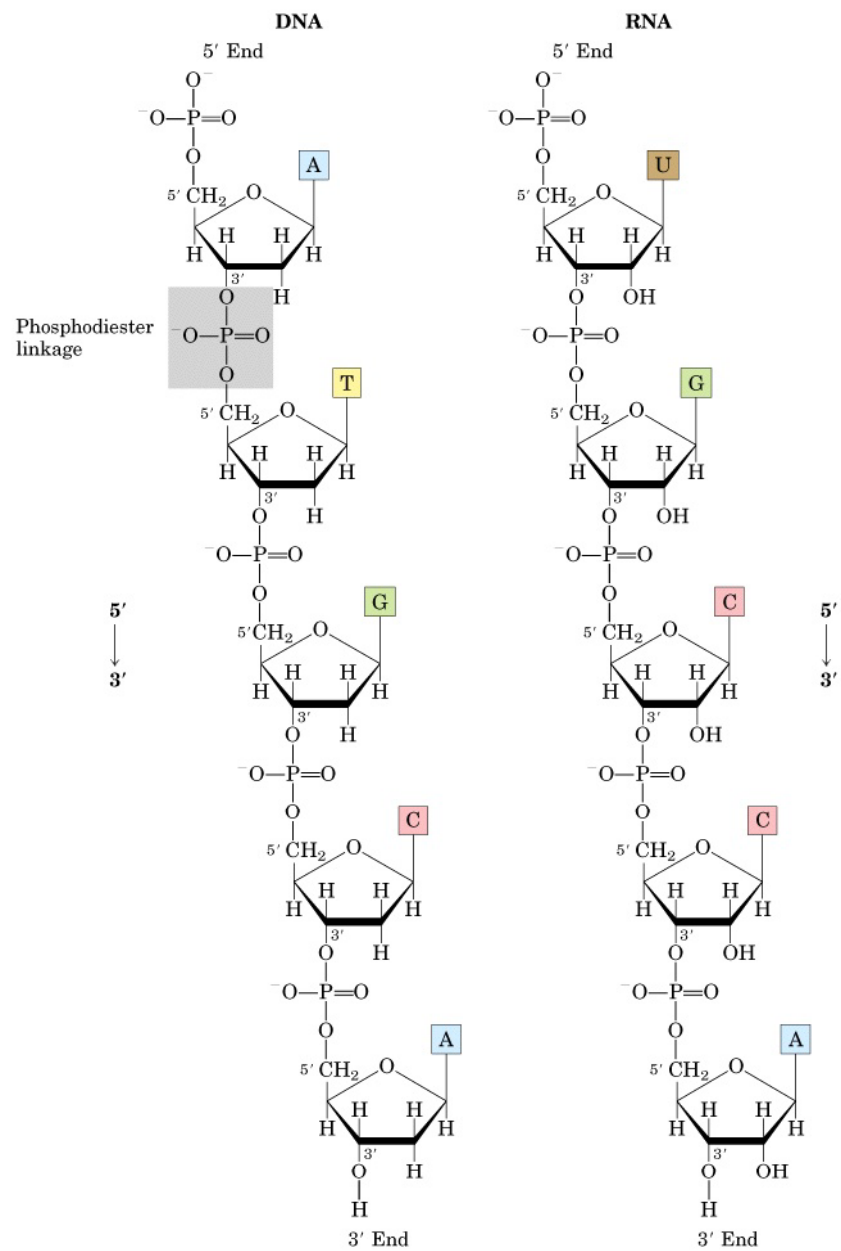


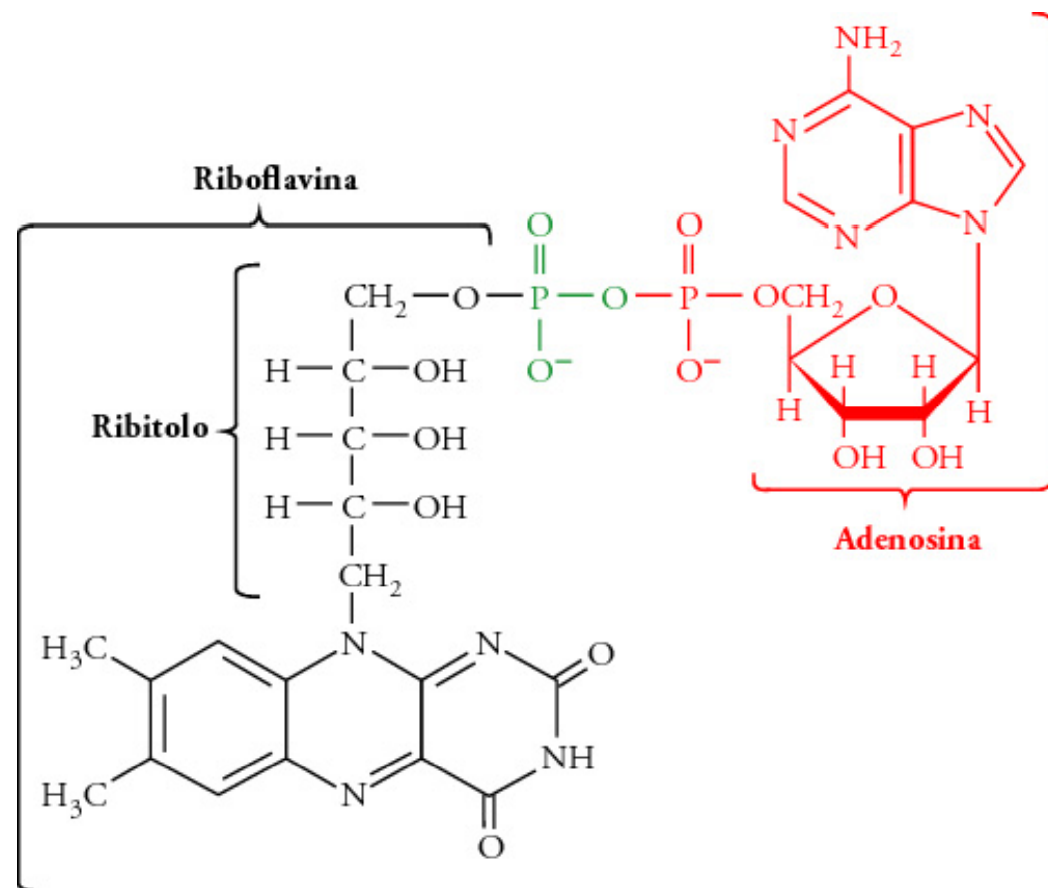
Nucleotide: Deoxycytidylate
(deoxycytidine
5'-monophosphate)

Symbols: C, dC, dCMP

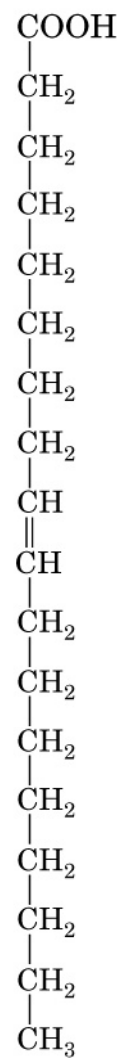
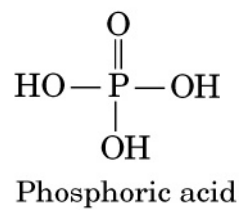
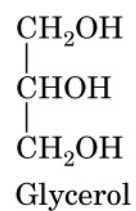
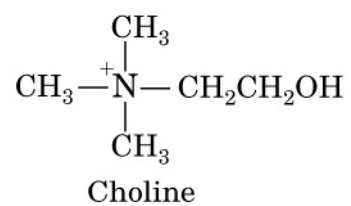
Nucleoside: Deoxycytidine

(a) Deoxyribonucleotides

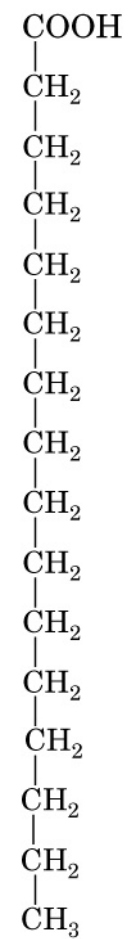




Some components of lipids



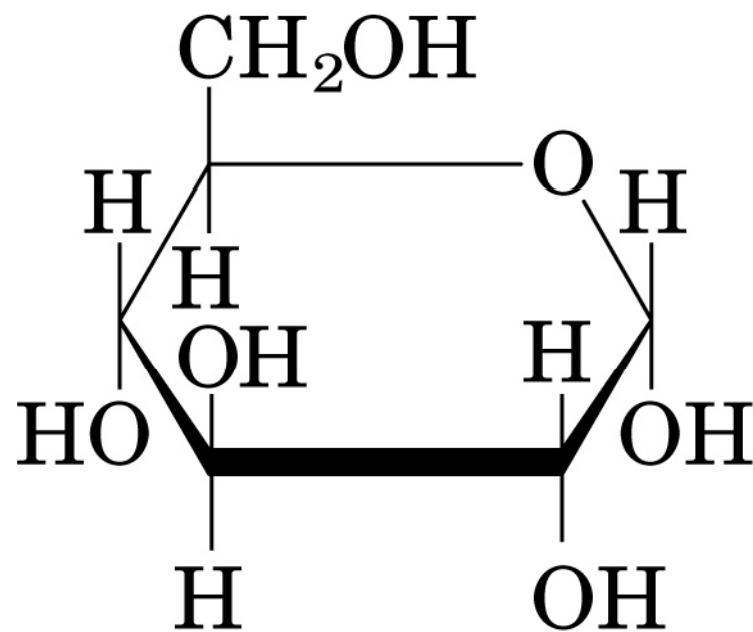
Oleic acid



Palmitic acid

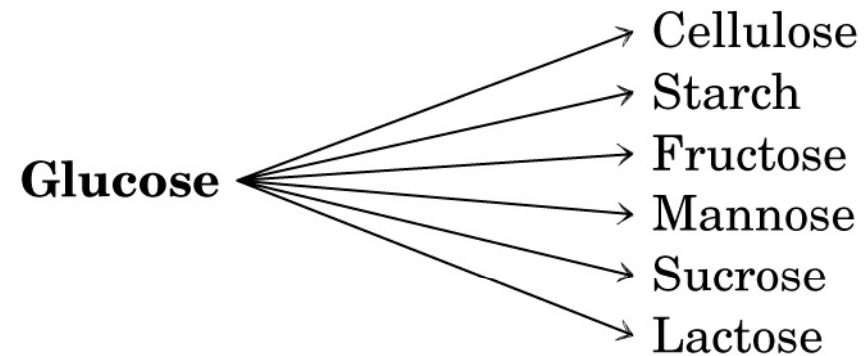
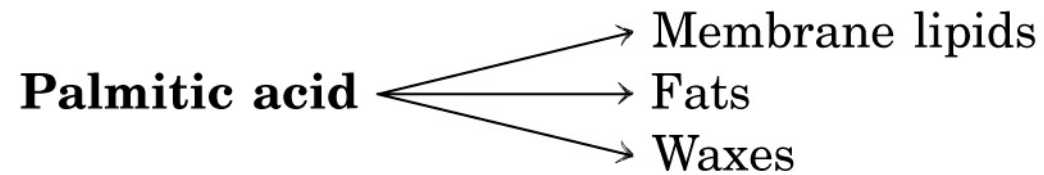
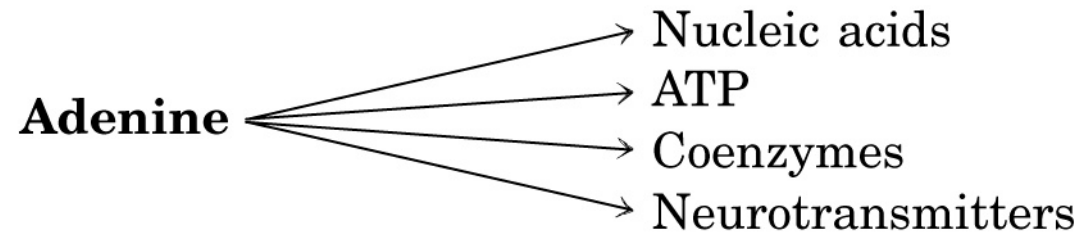
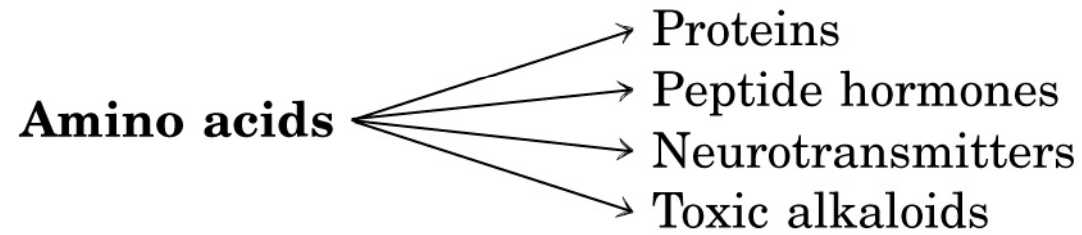
(c)

The parent sugar

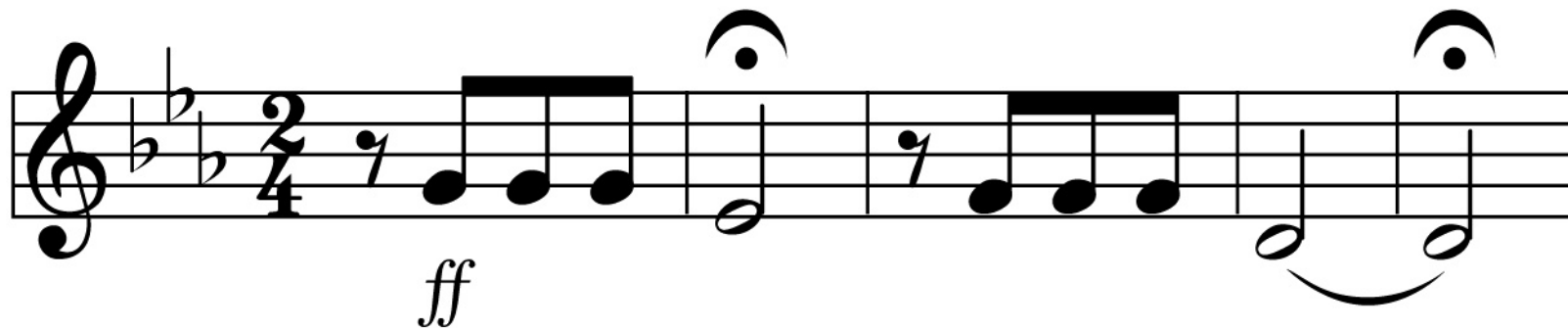


α -D-Glucose

(d)

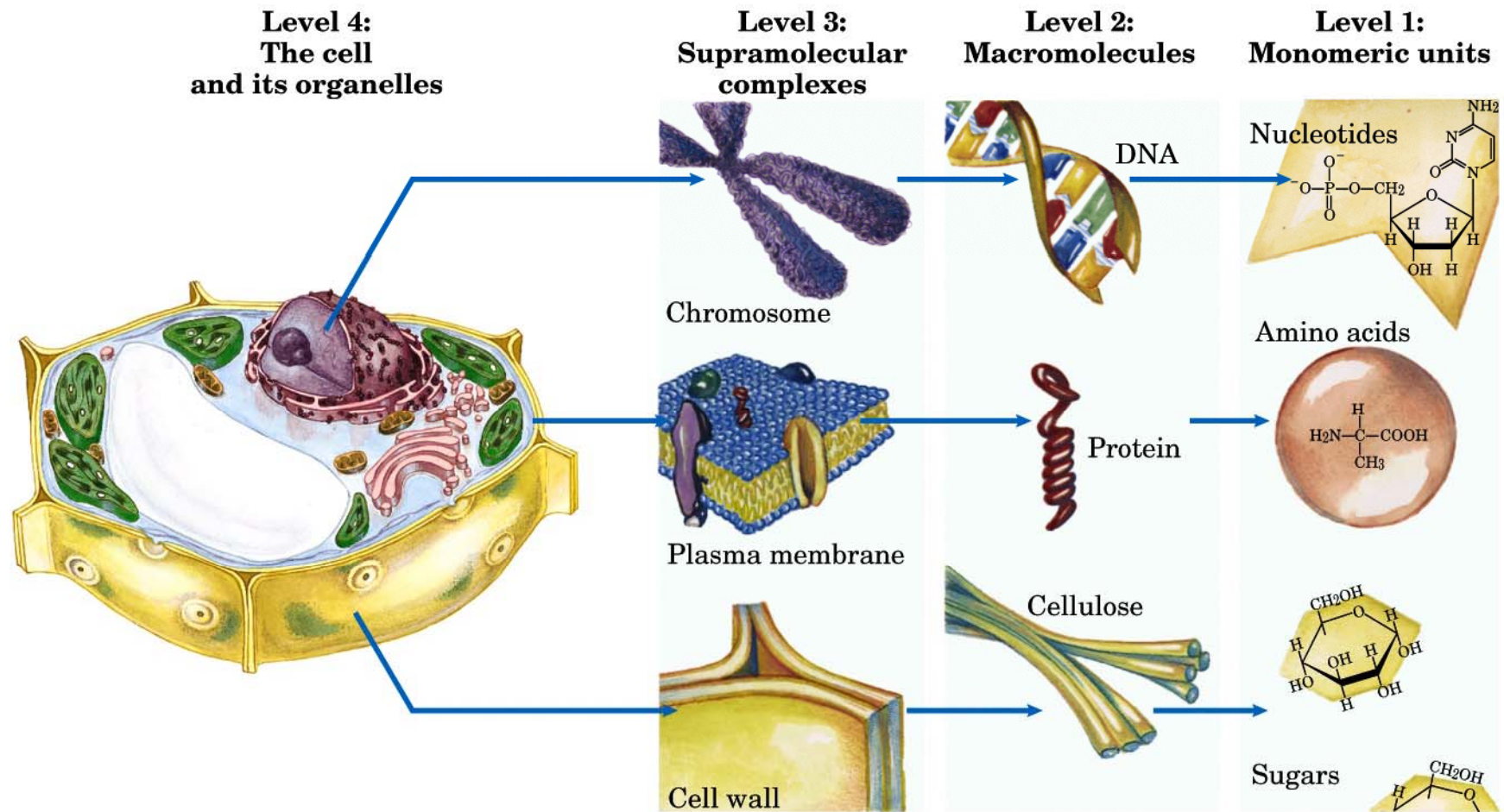


—A—C—T—C—G—A—C—G—A—
(DNA)

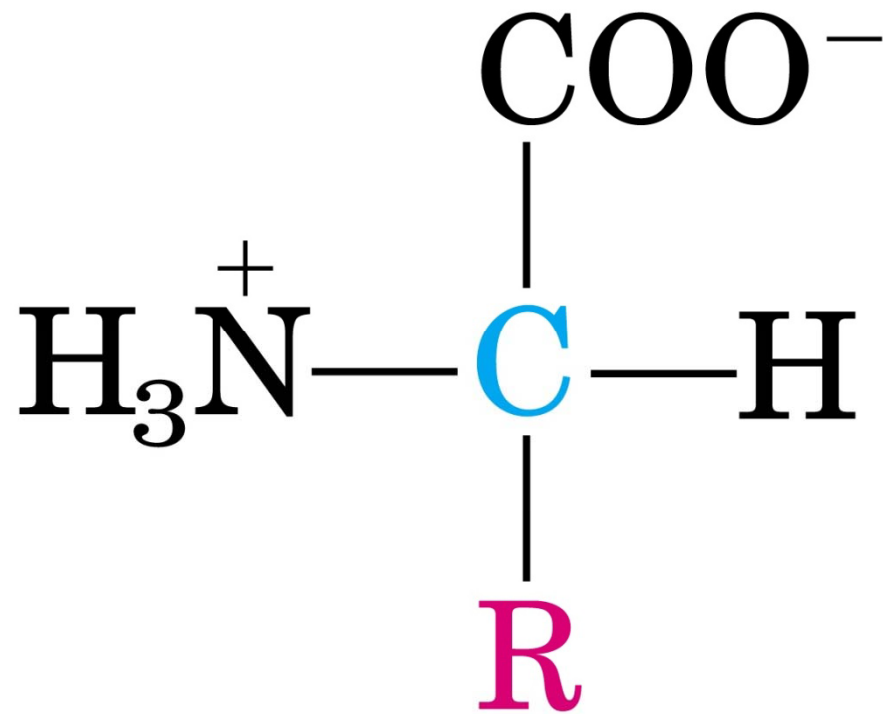


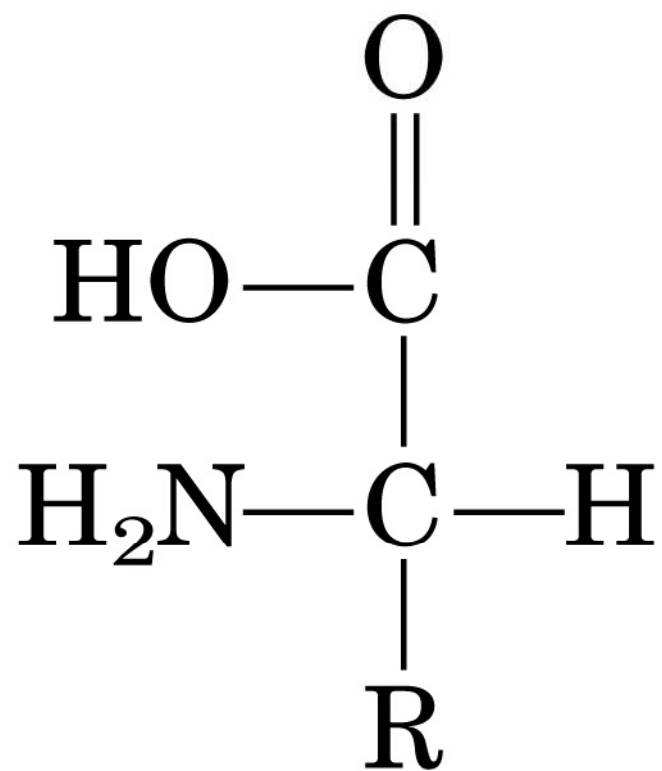
Glc — Glc — Glc — Glc — Glc —
(cellulose)



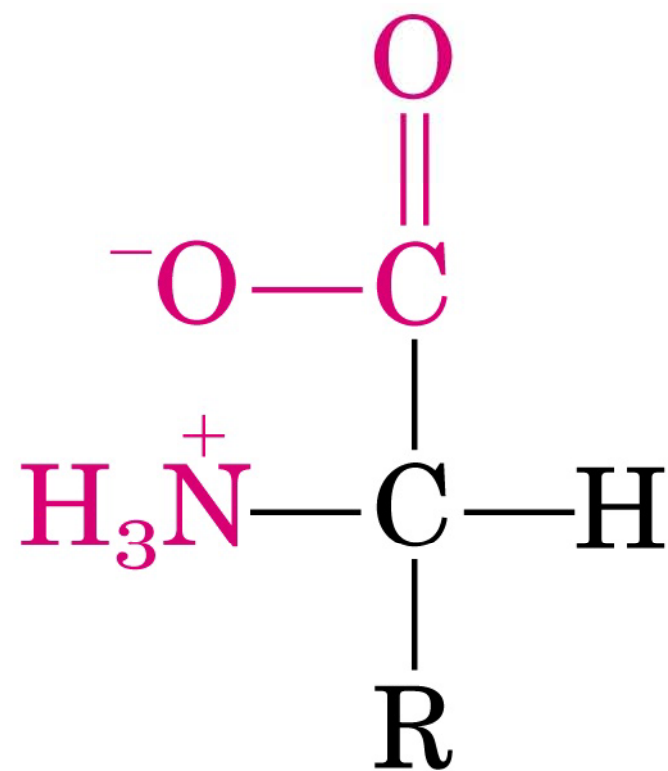


Gli aminoacidi

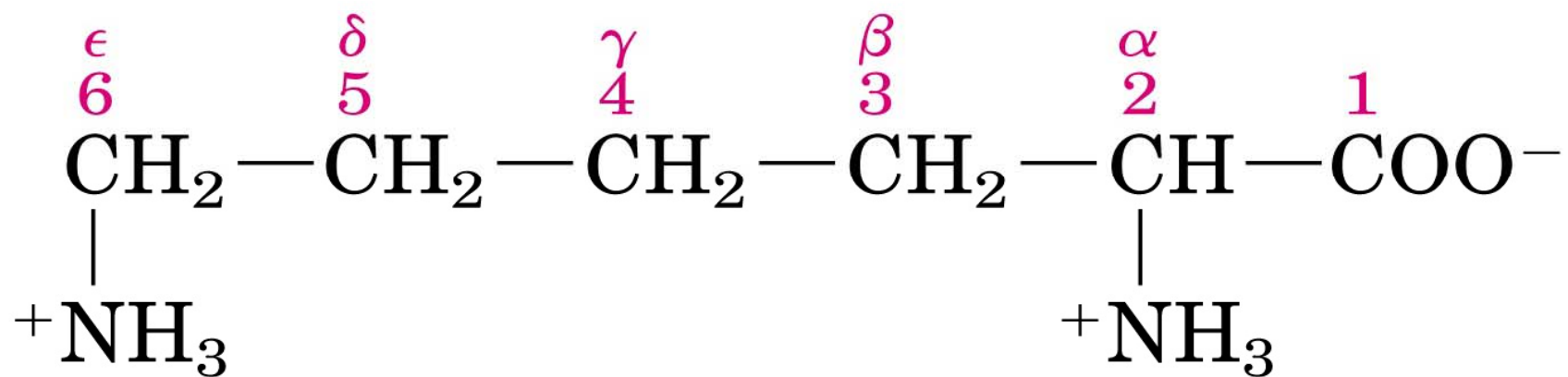




Nonionic
form



Zwitterionic
form



Lysine

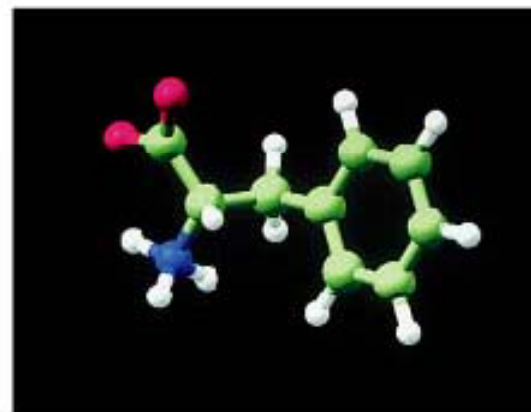
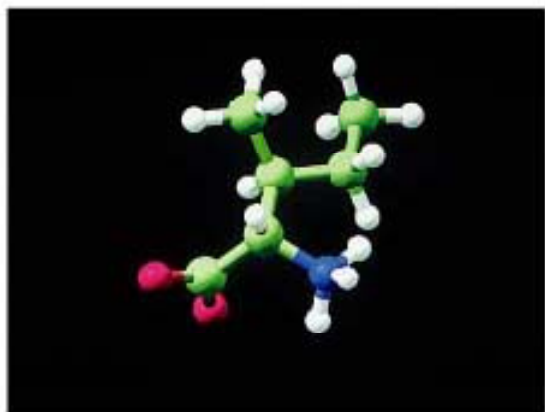
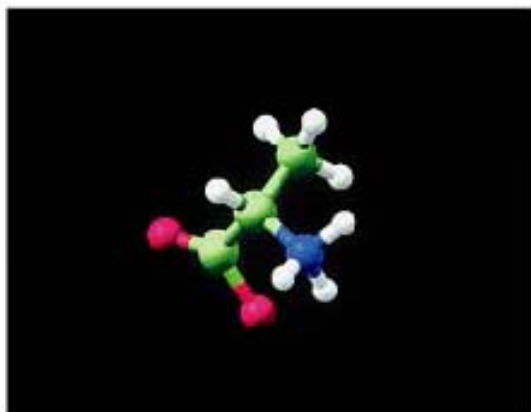
table 5–1

Properties and Conventions Associated with the Standard Amino Acids

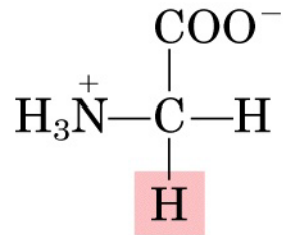
Amino acid	Abbreviated names		M_r	pK_a values			pI	Hydropathy index*	Occurrence in proteins (%)
				pK_1 (—COOH)	pK_2 (—NH ₃ ⁺)	pK_R (R group)			
Nonpolar, aliphatic R groups									
Glycine	Gly	G	75	2.34	9.60		5.97	−0.4	7.2
Alanine	Ala	A	89	2.34	9.69		6.01	1.8	7.8
Valine	Val	V	117	2.32	9.62		5.97	4.2	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
Polar, uncharged R groups									
Serine	Ser	S	105	2.21	9.15		5.68	−0.8	6.8
Proline	Pro	P	115	1.99	10.96		6.48	1.6	5.2
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 12. From Kyte, J. & Doolittle, R.F. (1982) *J. Mol. Biol.* **157**, 105–132.

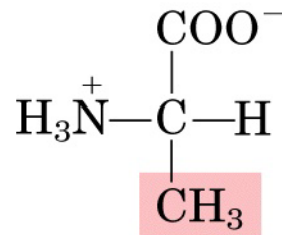
†Average occurrence in over 1150 proteins. From Doolittle, R.F. (1989) Redundancies in protein sequences. In *Prediction of Protein Structure and the Principles of Protein Conformation* (Fasman, G.D., ed) Plenum Press, NY, pp. 599–623.



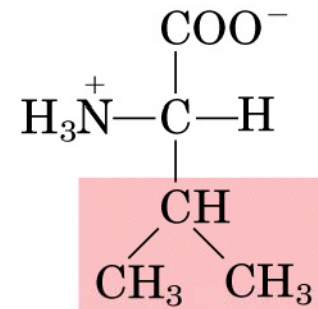
Nonpolar, aliphatic R groups



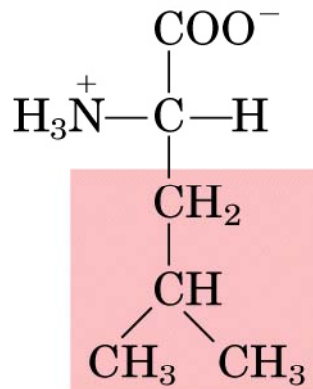
Glycine



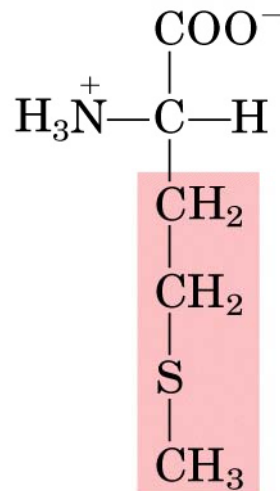
Alanine



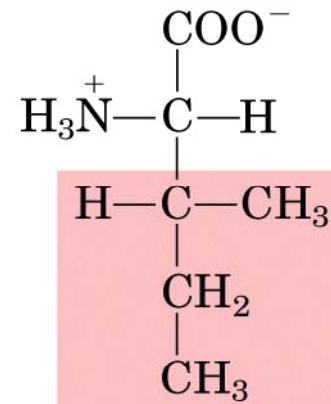
Valine



Leucine

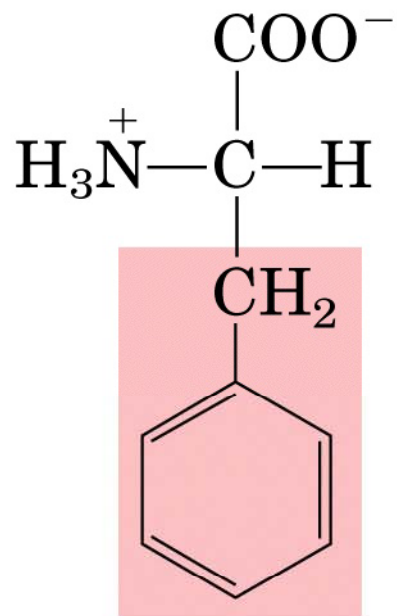


Methionine

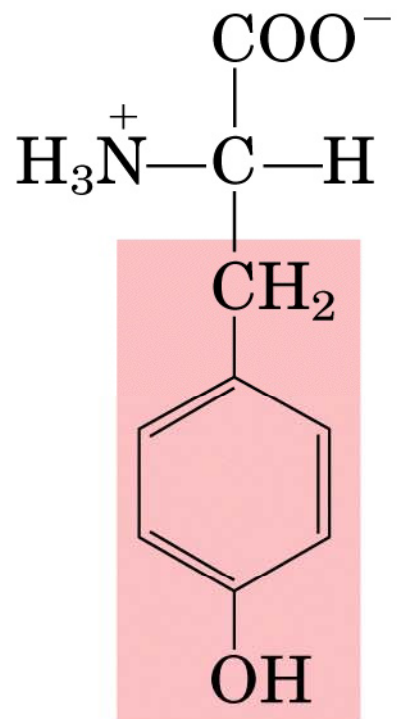


Isoleucine

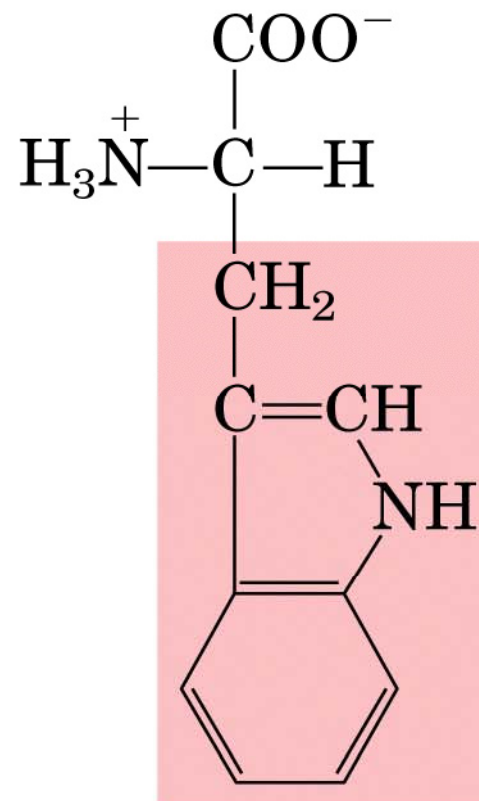
Aromatic R groups



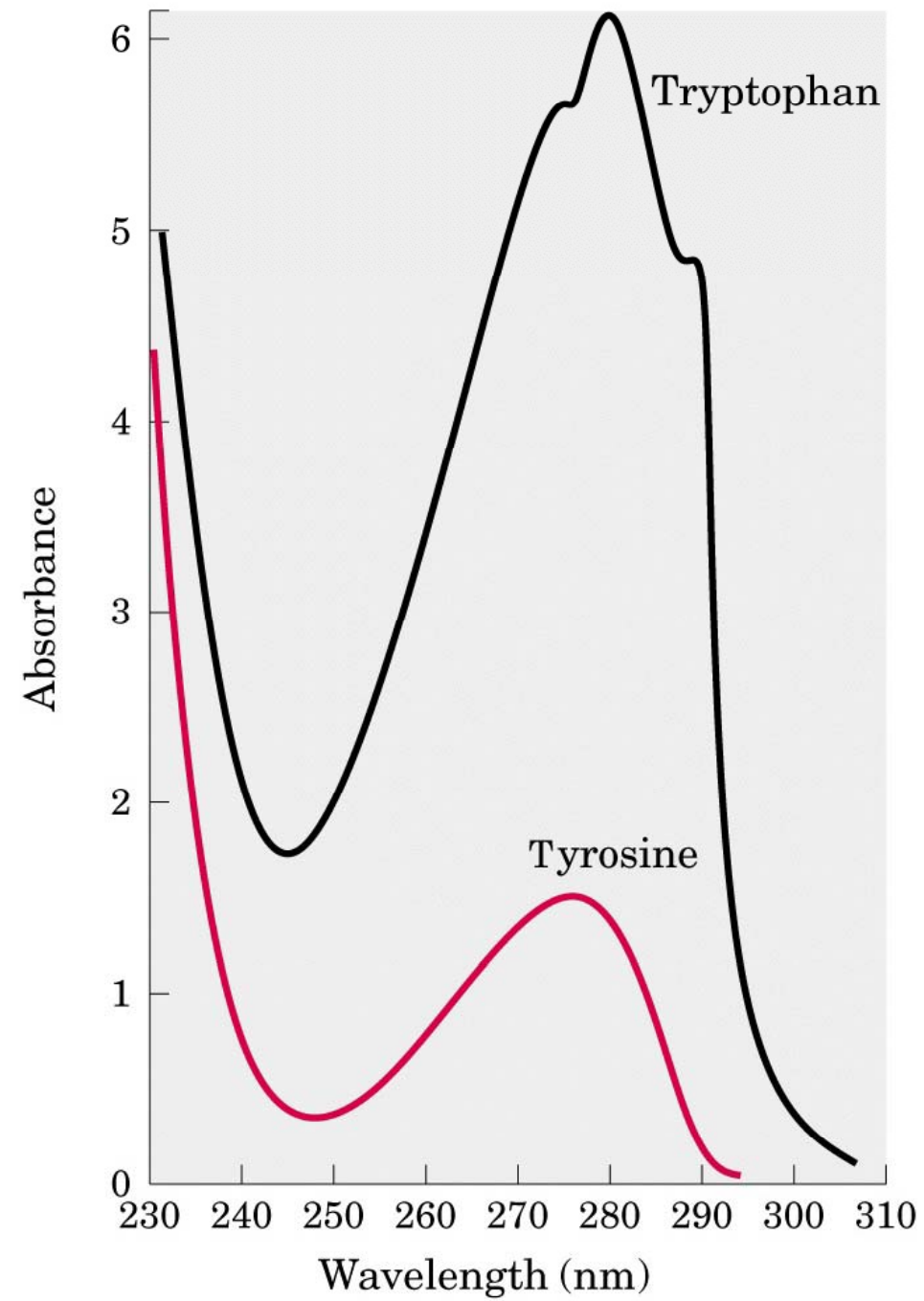
Phenylalanine



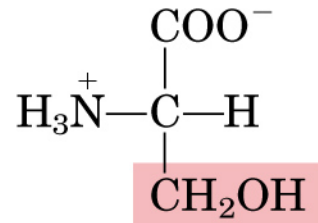
Tyrosine



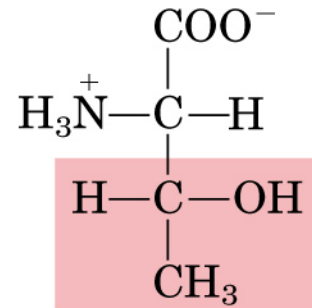
Tryptophan



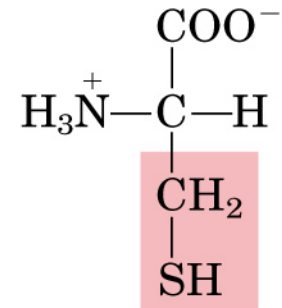
Polar, uncharged R groups



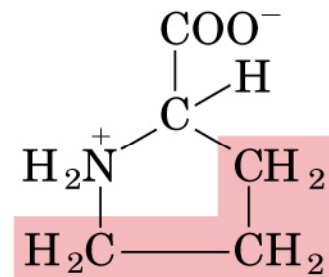
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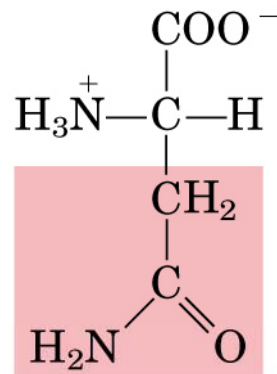
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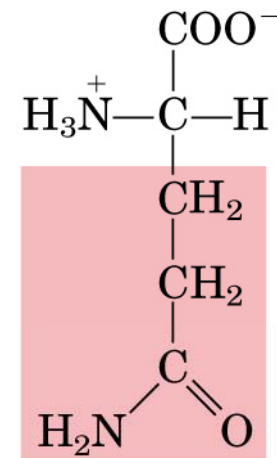
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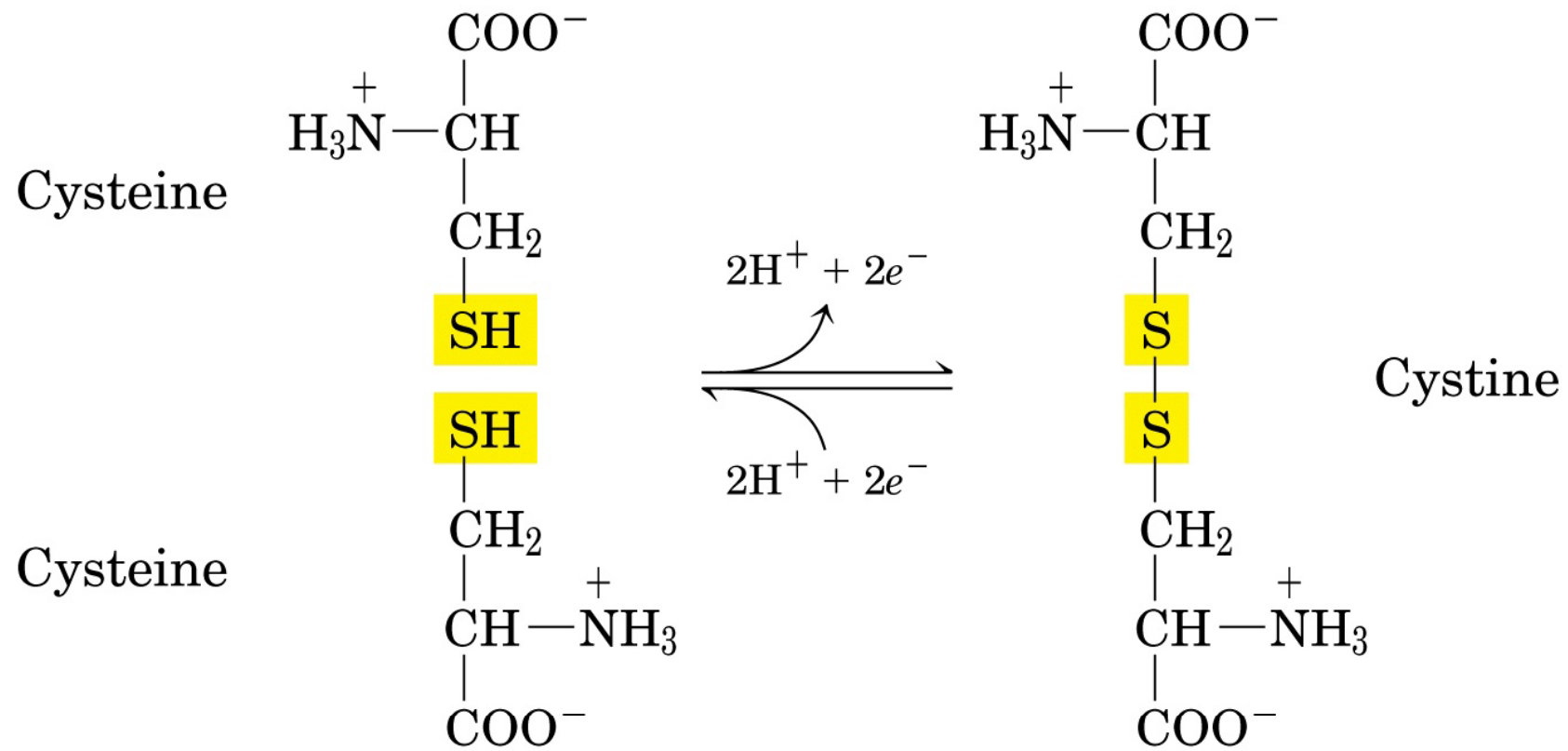
Proline



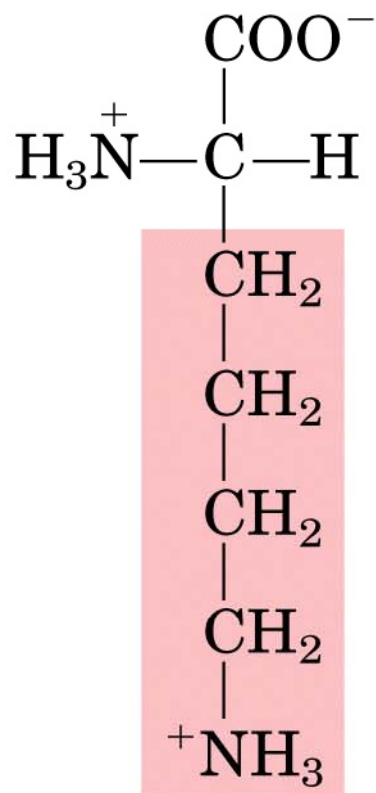
Asparagine



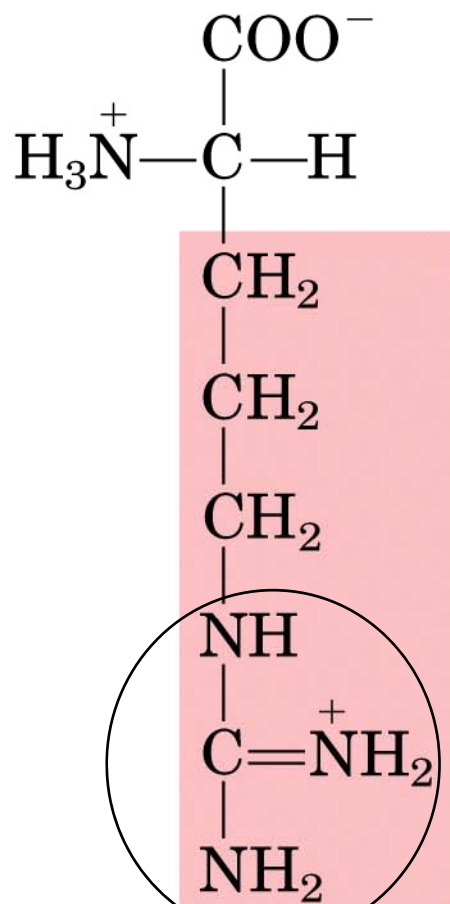
Glutamine



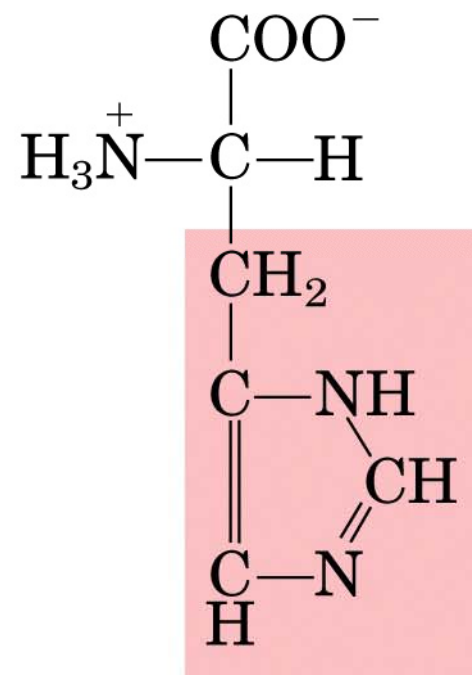
Positively charged R groups



Lysine

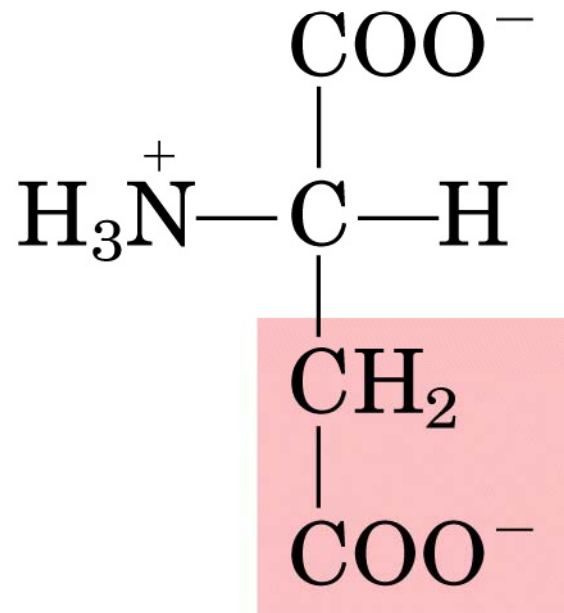


Arginine

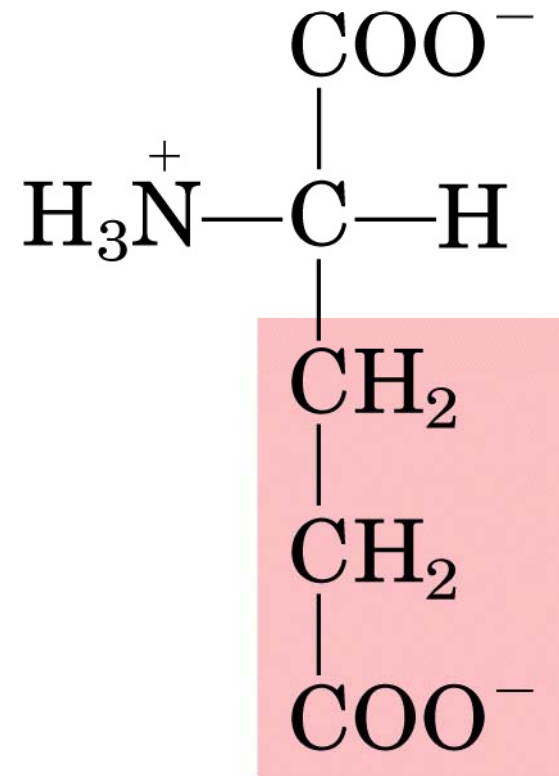


Histidine

Negatively charged R groups



Aspartate



Glutamate

Proprietà comuni

- Il gruppo α -carbossilico è un acido più forte del gruppo carbossilico degli acidi alifatici paragonabili
- Il gruppo α -aminico è un acido più forte (o una base più debole del gruppo aminico di amine alifatiche corrispondenti
- Tutti gli aminoacidi con gruppi R privi di carica hanno valori pK_1 e pK_2 molto simili tra loro
- L'unico aminoacido con una capacità tampone degna di nota a pH fisiologico è l'istidina

table 5–1

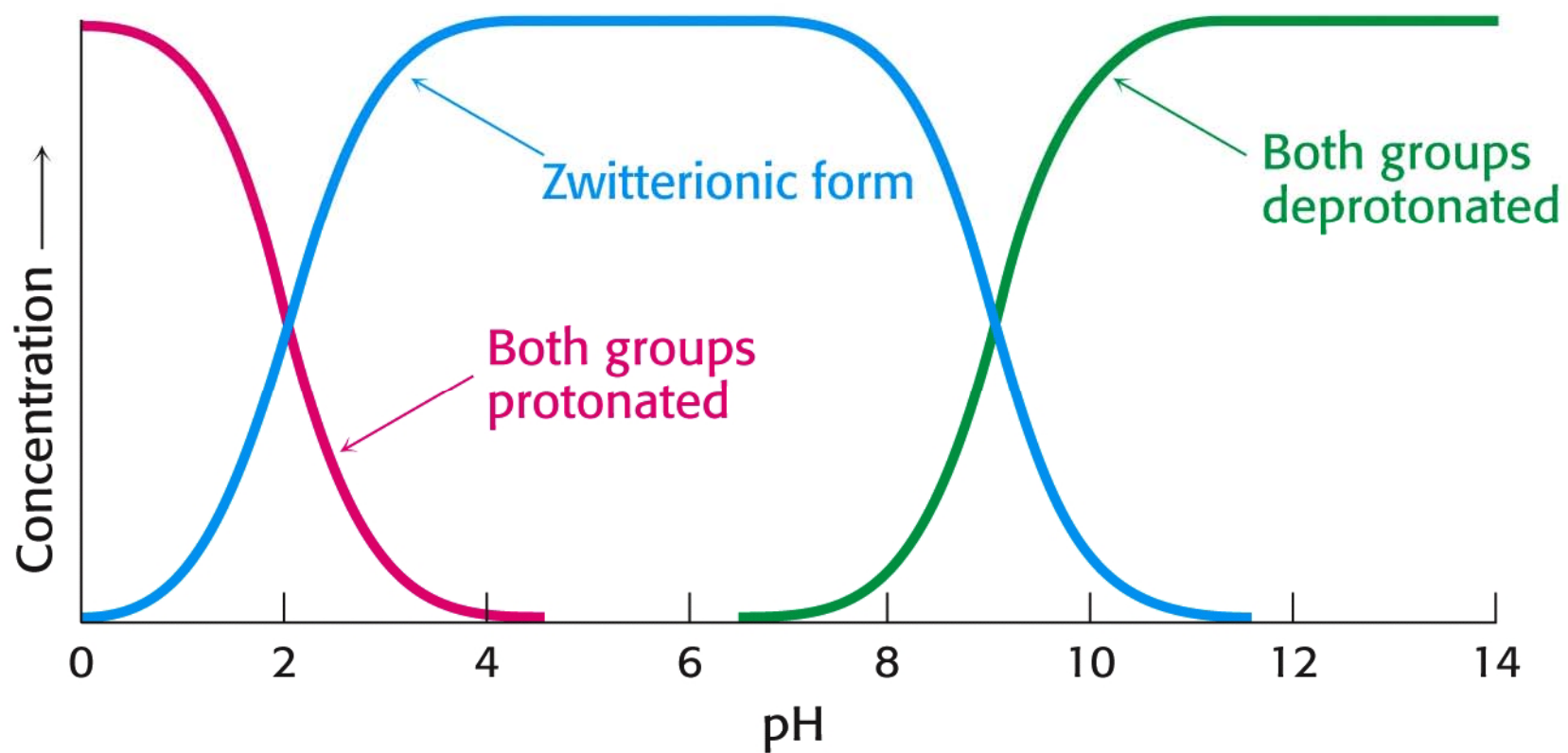
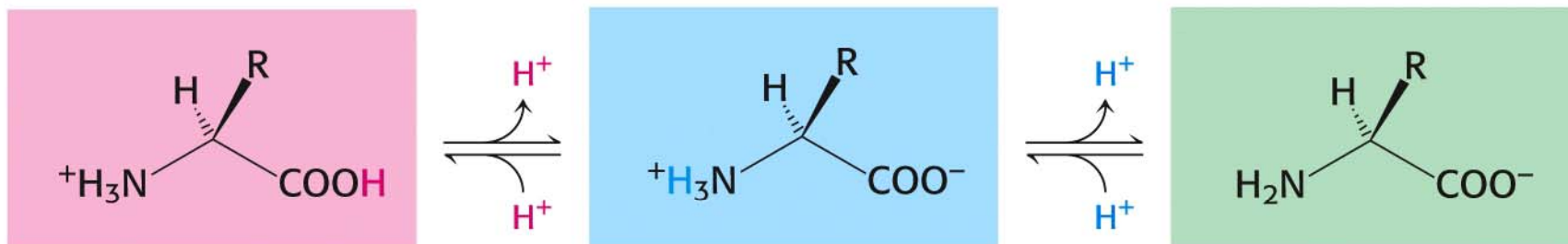
Properties and Conventions Associated with the Standard Amino Acids

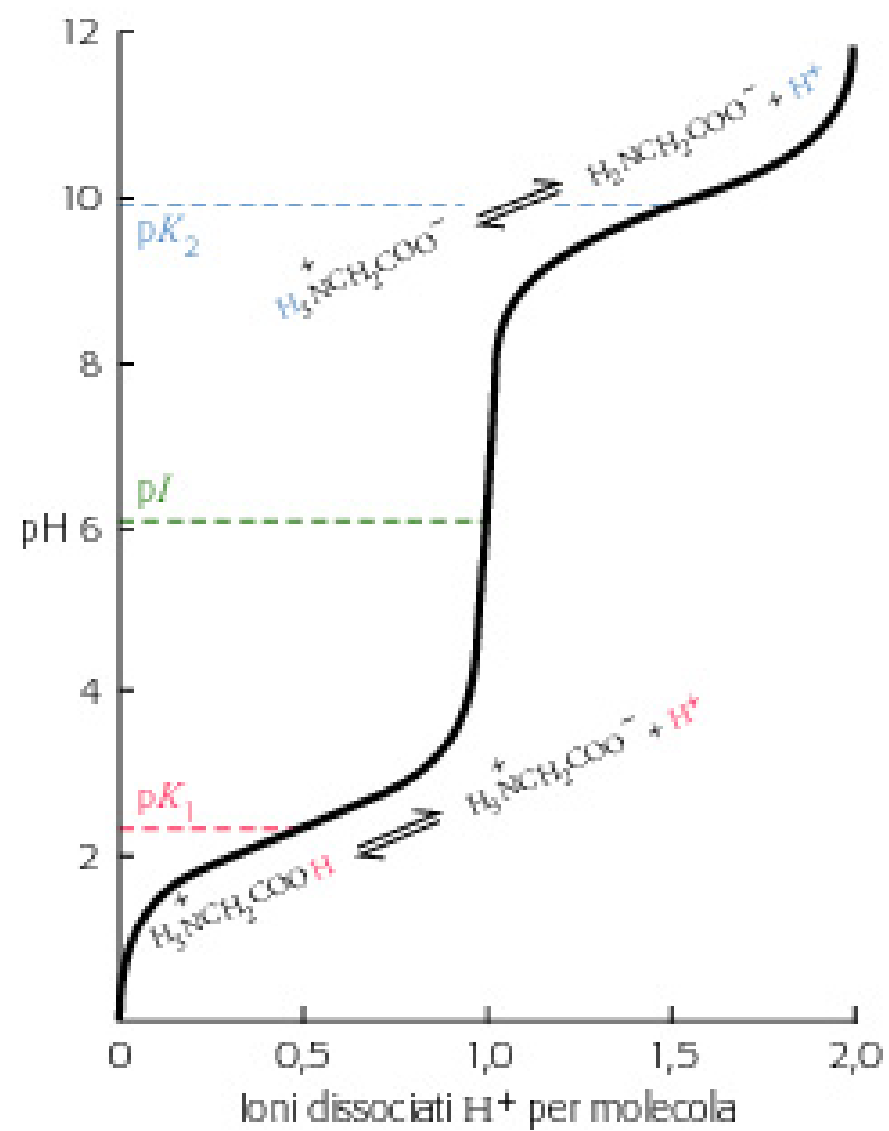
Amino acid	Abbreviated names		M_r	pK_a values			pI	Hydropathy index*	Occurrence in proteins (%)
				pK_1 (—COOH)	pK_2 (—NH ₃ ⁺)	pK_R (R group)			
Nonpolar, aliphatic R groups									
Glycine	Gly	G	75	2.34	9.60		5.97	−0.4	7.2
Alanine	Ala	A	89	2.34	9.69		6.01	1.8	7.8
Valine	Val	V	117	2.32	9.62		5.97	4.2	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
Polar, uncharged R groups									
Serine	Ser	S	105	2.21	9.15		5.68	−0.8	6.8
Proline	Pro	P	115	1.99	10.96		6.48	1.6	5.2
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

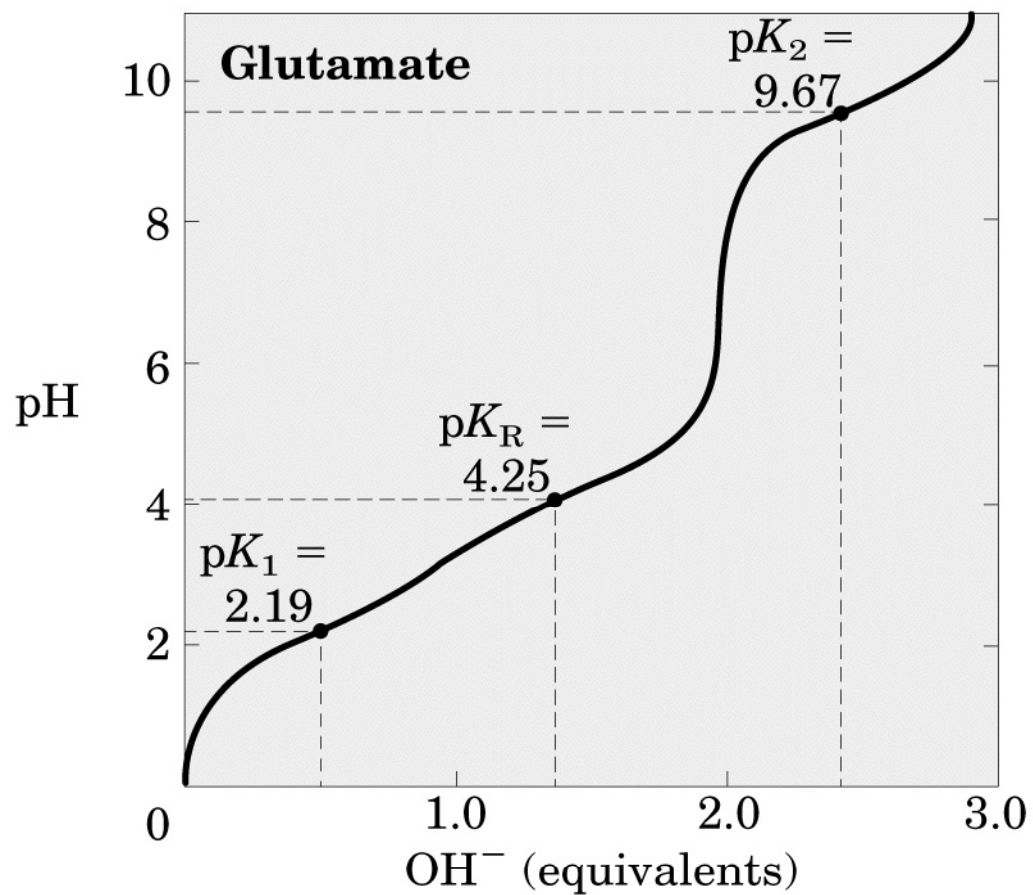
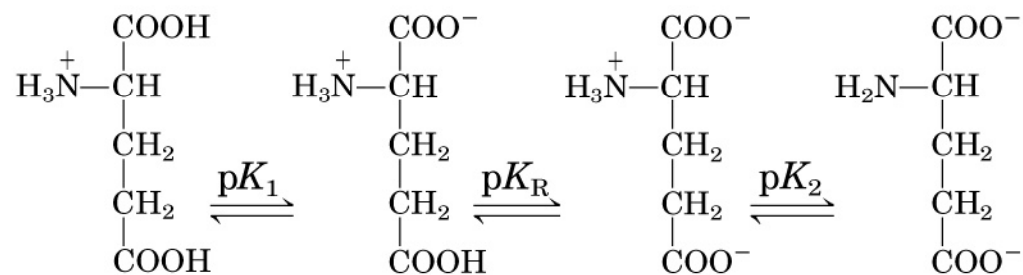
*A scale combining hydrophobicity and hydrophilicity of R groups; it can be used to measure the tendency of an amino acid to seek an aqueous environment (– values) or a hydrophobic environment (+ values). See Chapter 12. From Kyte, J. & Doolittle, R.F. (1982) *J. Mol. Biol.* **157**, 105–132.

†Average occurrence in over 1150 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) Plenum Press, NY, pp. 599–623.

pK_a	2	4	6	8	10	12
Methyl-substituted carboxyl and amino groups		$\text{CH}_3\text{---COOH} \xrightleftharpoons[\text{H}^+]{\text{H}^+} \text{CH}_3\text{---COO}^-$ Acetic acid The normal pK_a for a carboxyl group is about 4.8.			$\text{CH}_3\text{---NH}_3^+ \xrightleftharpoons[\text{H}^+]{\text{H}^+} \text{CH}_3\text{---NH}_2$ Methylamine The normal pK_a for an amino group is about 10.6.	
Carboxyl and amino groups in glycine	$\begin{array}{c} \text{NH}_3^+ \\ \\ \text{H---C---COOH} \\ \\ \text{H} \end{array} \xrightleftharpoons[\text{H}^+]{\text{H}^+}$ α-Amino acid (glycine) $pK_a = 2.34$ Repulsion between the amino group and the departing proton lowers the pK_a for the carboxyl group, and oppositely charged groups lower the pK_a by stabi- lizing the zwitterion.		$\begin{array}{c} \text{NH}_3^+ \\ \\ \text{H---C---COO}^- \\ \\ \text{H} \end{array}$		$\begin{array}{c} \text{NH}_2 \\ \\ \text{H---C---COO}^- \\ \\ \text{H} \end{array} \xrightleftharpoons[\text{H}^+]{\text{H}^+}$ α-Amino acid (glycine) $pK_a = 9.60$ Electronegative oxygen atoms in the carboxyl group pull electrons away from the amino group, lowering its pK_a.	







(a)

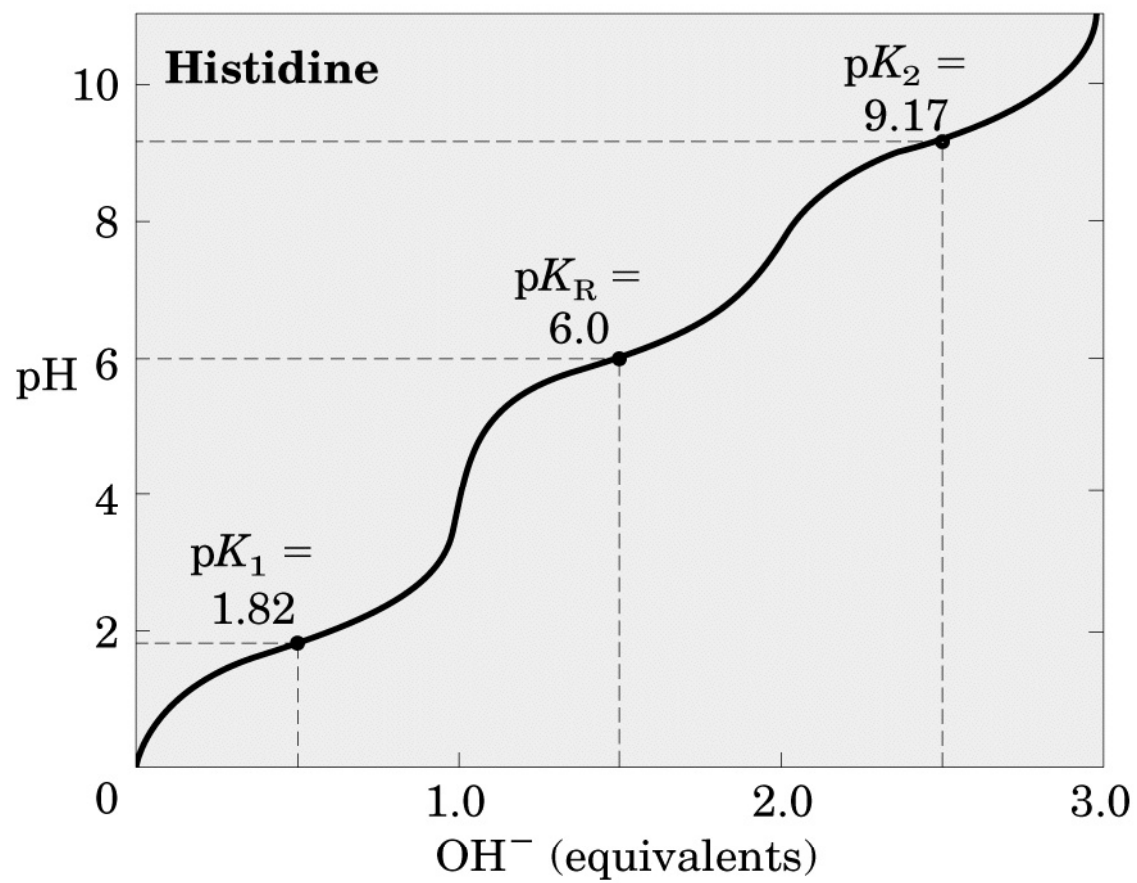
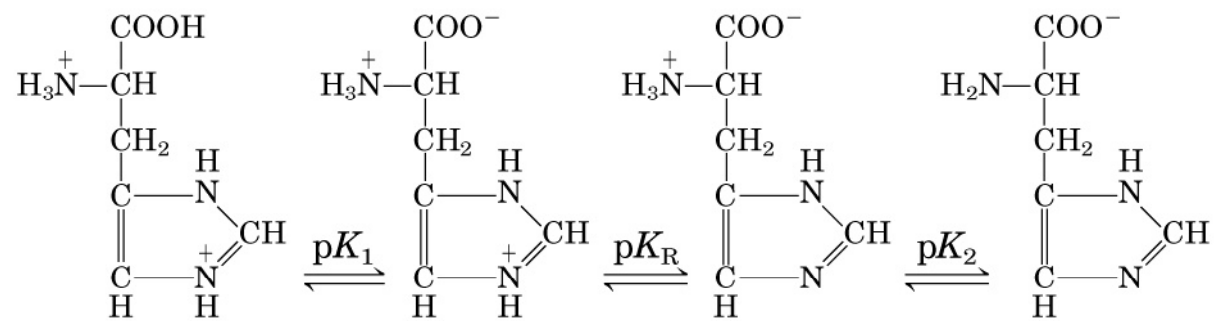
table 5–1

Properties and Conventions Associated with the Standard Amino Acids

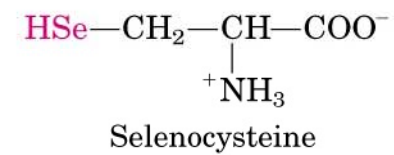
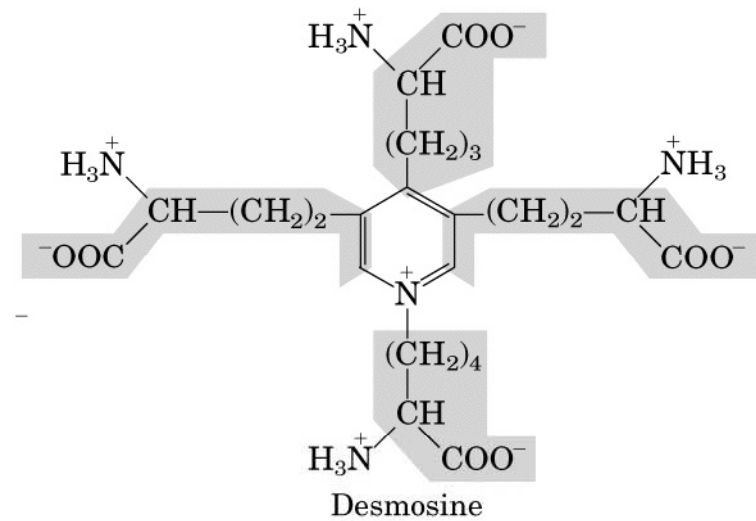
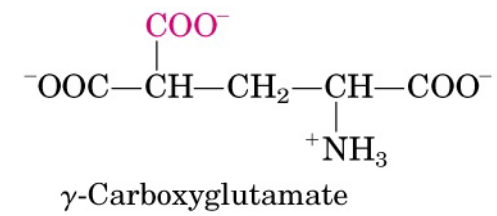
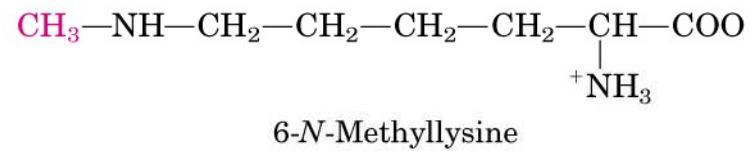
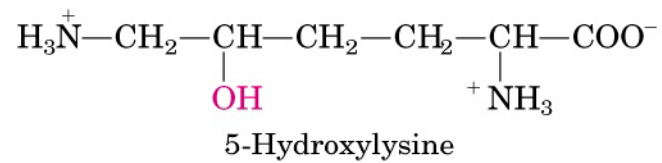
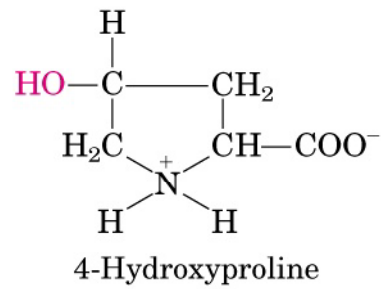
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*A scale combining hydrophobicity and hydrophilicity of R groups; it can be used to measure the tendency of an amino acid to seek an aqueous environment (– values) or a hydrophobic environment (+ values). See Chapter 12. From Kyte, J. & Doolittle, R.F. (1982) *J. Mol. Biol.* **157**, 105–132.

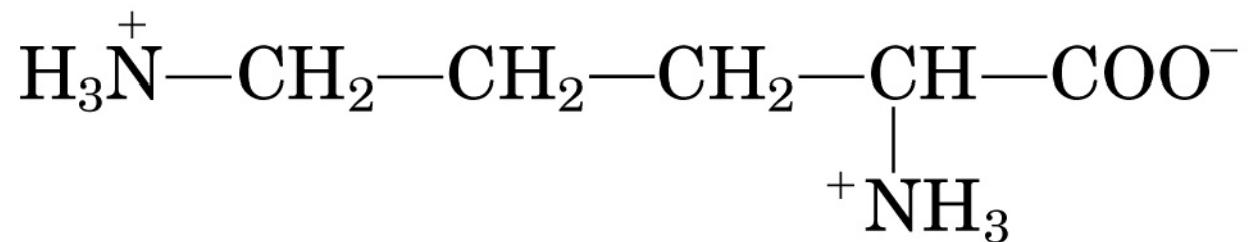
†Average occurrence in over 1150 proteins. From Doolittle, R.F. (1989) Redundancies in protein sequences. In *Prediction of Protein Structure and the Principles of Protein Conformation* (Fasman, G.D., ed) Plenum Press, NY, pp. 599–623.



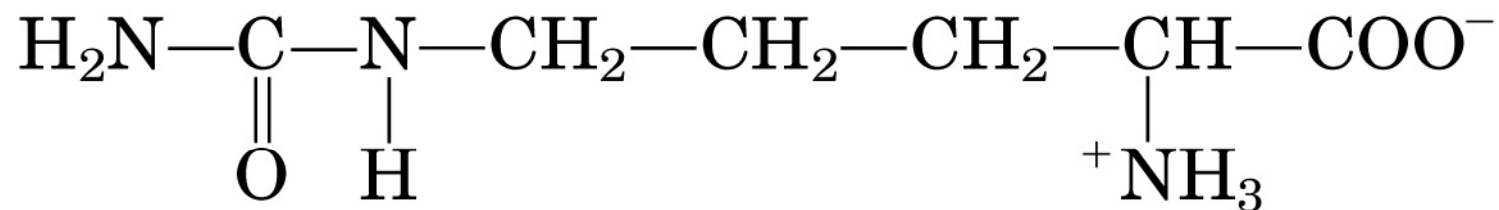
(b)



(a)



Ornithine



Citrulline

(b)

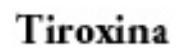
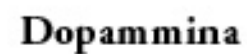
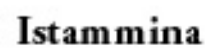
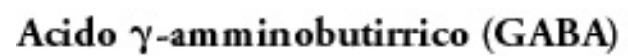


table 5–2

Molecular Data on Some Proteins

	Molecular weight	Number of residues	Number of polypeptide chains
Cytochrome c (human)	13,000	104	1
Ribonuclease A (bovine pancreas)	13,700	124	1
Lysozyme (egg white)	13,930	129	1
Myoglobin (equine heart)	16,890	153	1
Chymotrypsin (bovine pancreas)	21,600	241	3
Chymotrypsinogen (bovine)	22,000	245	1
Hemoglobin (human)	64,500	574	4
Serum albumin (human)	68,500	609	1
Hexokinase (yeast)	102,000	972	2
RNA polymerase (<i>E. coli</i>)	450,000	4,158	5
Apolipoprotein B (human)	513,000	4,536	1
Glutamine synthetase (<i>E. coli</i>)	619,000	5,628	12
Titin (human)	2,993,000	26,926	1

table 5-3

Amino Acid Composition of Two Proteins*		
Amino acid	Number of residues per molecule of protein	
	Bovine cytochrome c	Bovine chymotrypsinogen
Ala	6	22
Arg	2	4
Asn	5	15
Asp	3	8
Cys	2	10
Gln	3	10
Glu	9	5
Gly	14	23
His	3	2
Ile	6	10
Leu	6	19
Lys	18	14
Met	2	2
Phe	4	6
Pro	4	9
Ser	1	28
Thr	8	23
Trp	1	8
Tyr	4	4
Val	3	23
Total	104	245

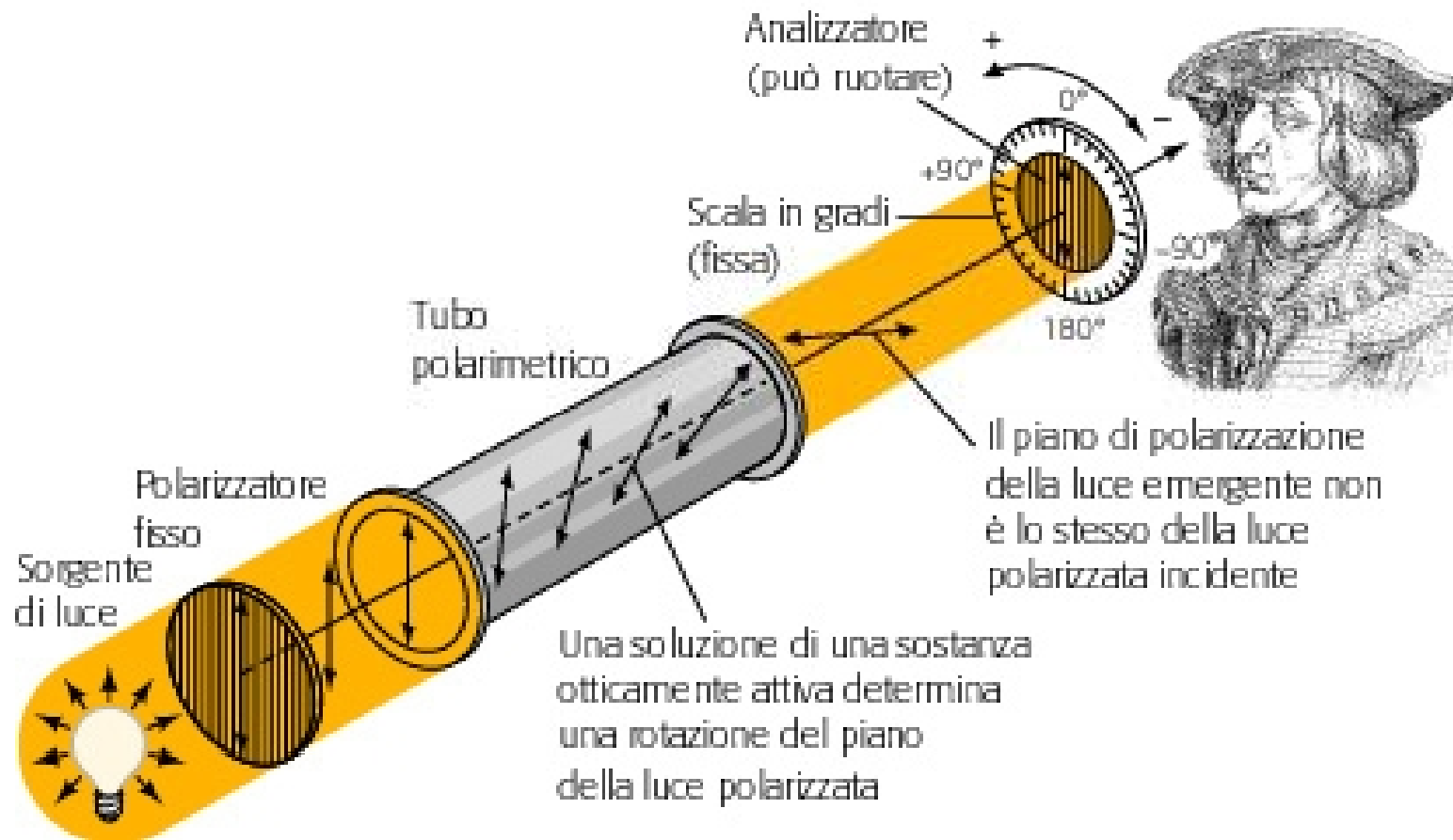
*Note that standard procedures for the acid hydrolysis of proteins convert Asn and Gln to Asp and Glu, respectively. In addition, Trp is destroyed. Special procedures must be employed to determine the amounts of these amino acids.

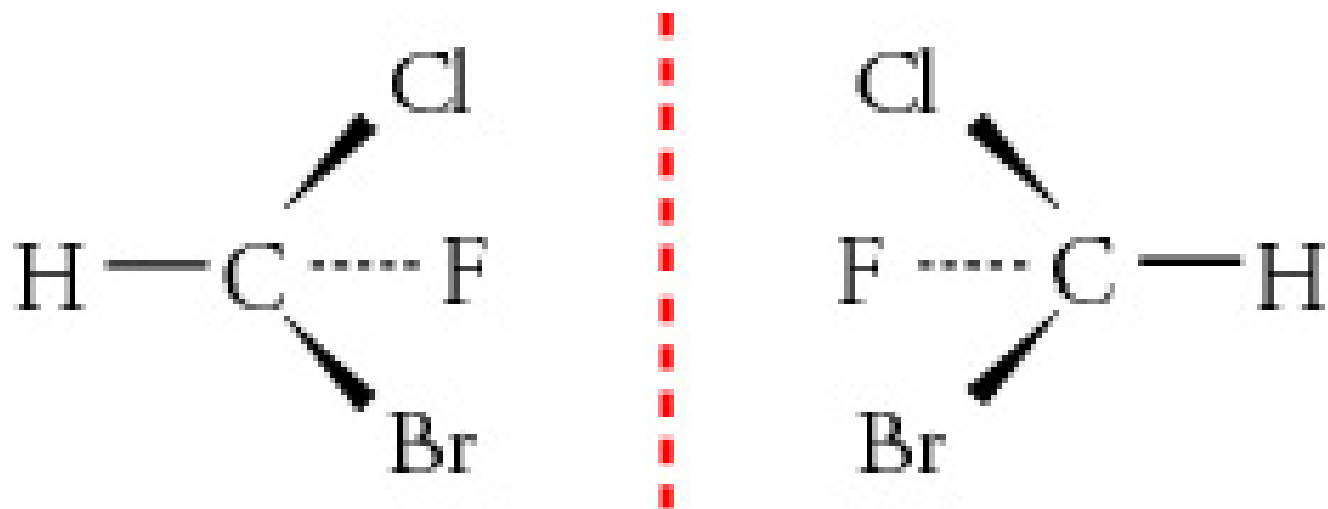
table 5–4

Conjugated Proteins

Class	Prosthetic group(s)	Example
Lipoproteins	Lipids	β_1 -Lipoprotein of blood
Glycoproteins	Carbohydrates	Immunoglobulin G
Phosphoproteins	Phosphate groups	Casein of milk
Hemoproteins	Heme (iron porphyrin)	Hemoglobin
Flavoproteins	Flavin nucleotides	Succinate dehydrogenase
Metalloproteins	Iron	Ferritin
	Zinc	Alcohol dehydrogenase
	Calcium	Calmodulin
	Molybdenum	Dinitrogenase
	Copper	Plastocyanin

**Tutti gli aminoacidi, a parte la glicina, sono otticamente attivi:
ruotano il piano della luce polarizzata**

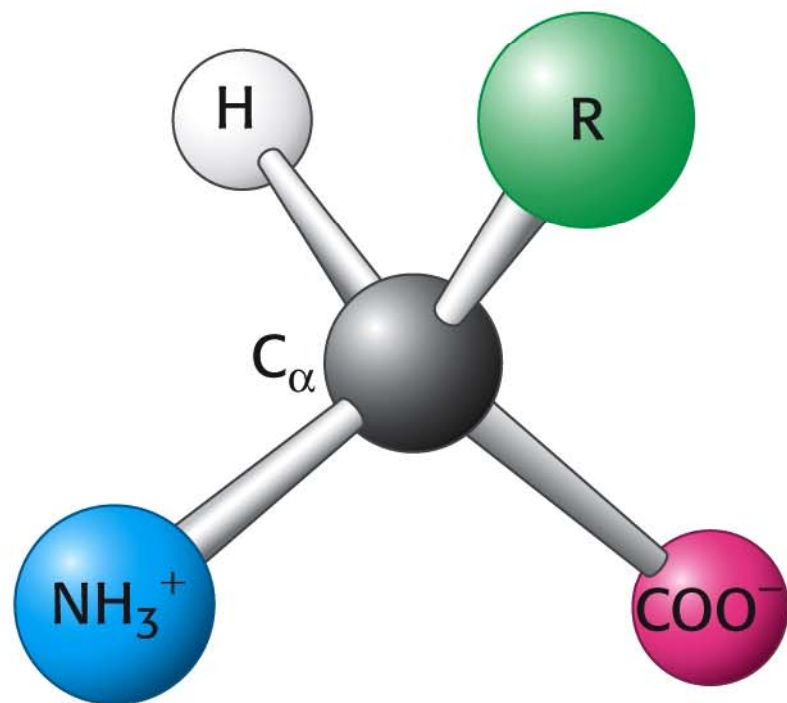




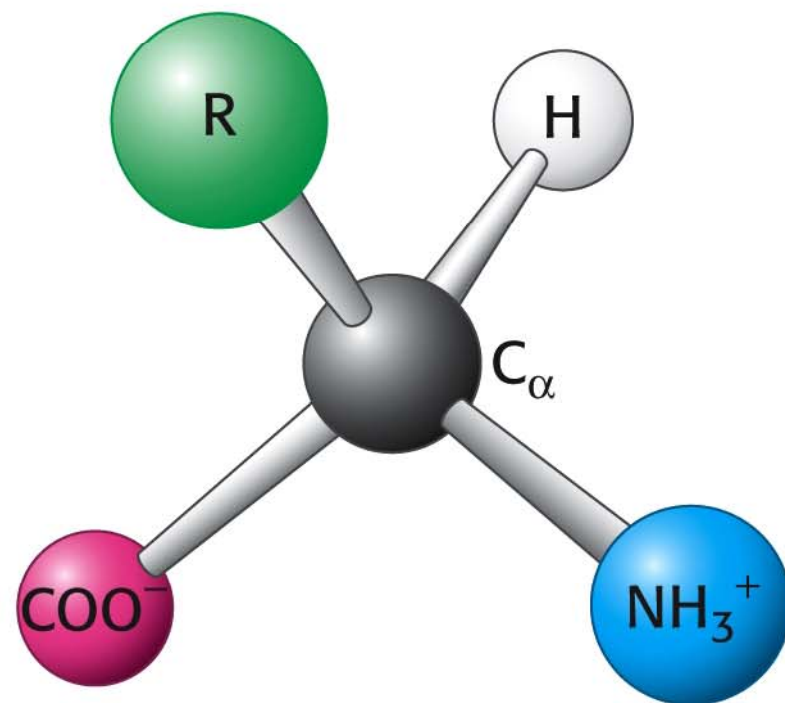
Piano dello specchio

In questa molecola l'atomo di carbonio è detto **centro asimmetrico** o **centro chiralico**

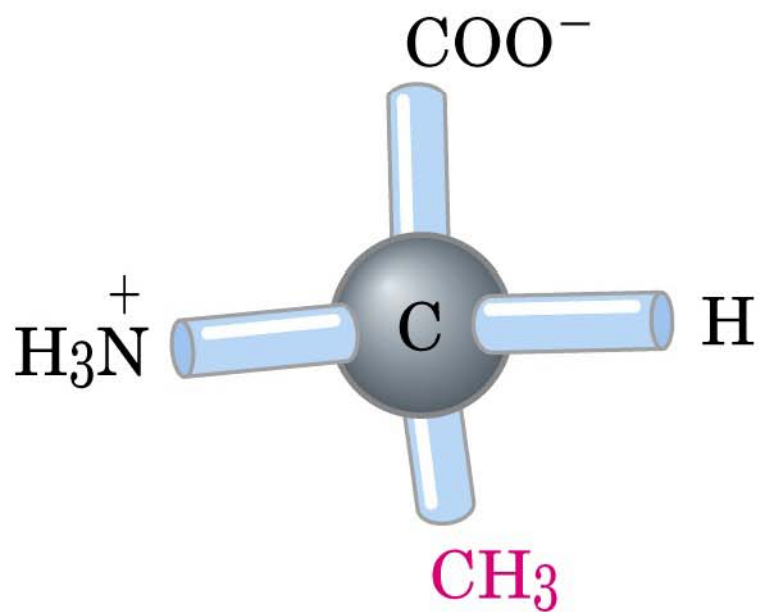
I due isomeri sono chiamati **enantiomeri**



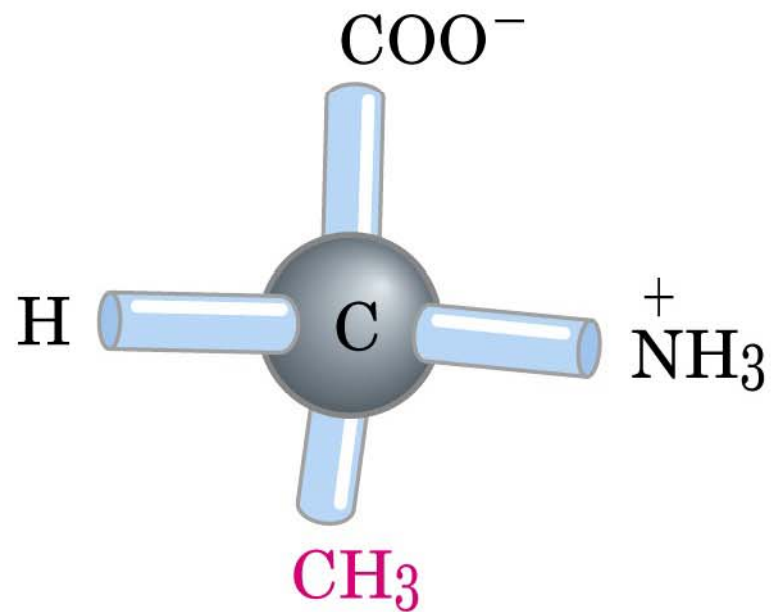
L isomer



D isomer



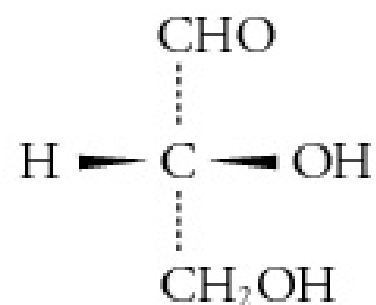
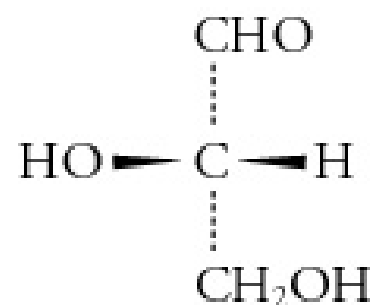
L-Alanine



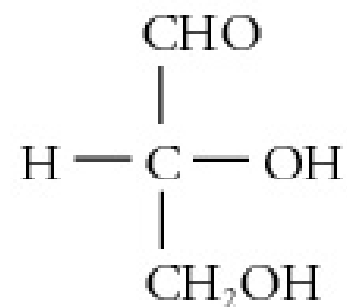
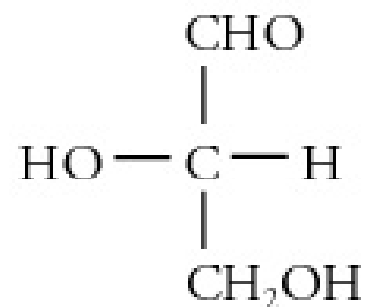
D-Alanine

(a)

Formule geometriche



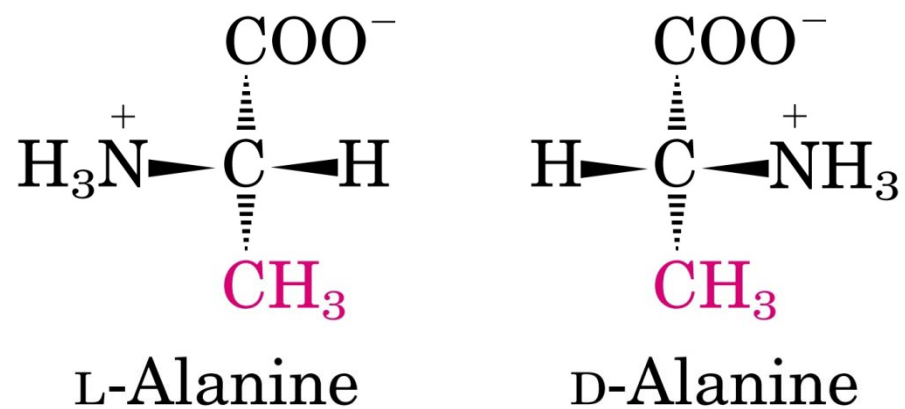
Proiezioni di Fischer



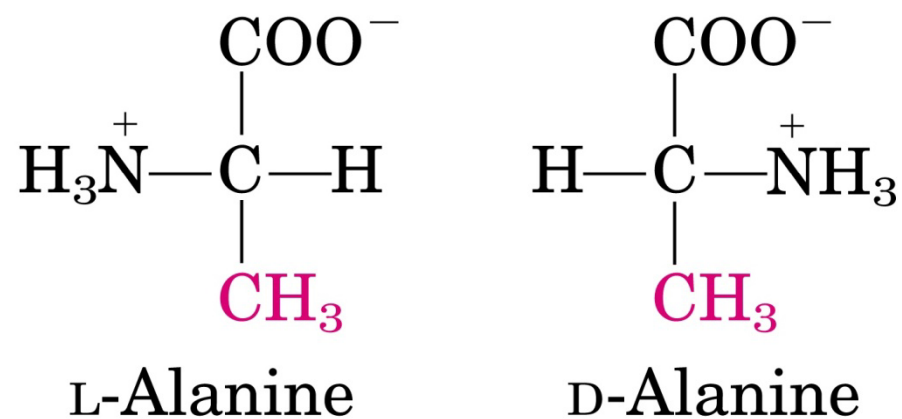
Piano dello specchio

L-Gliceraldeide

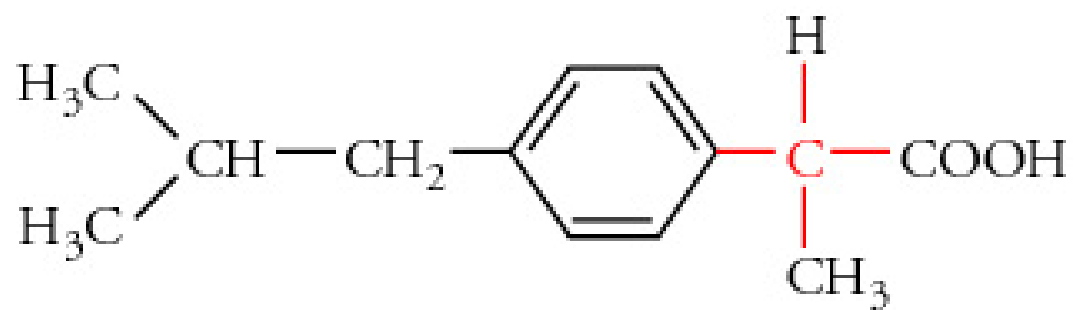
D-Gliceraldeide



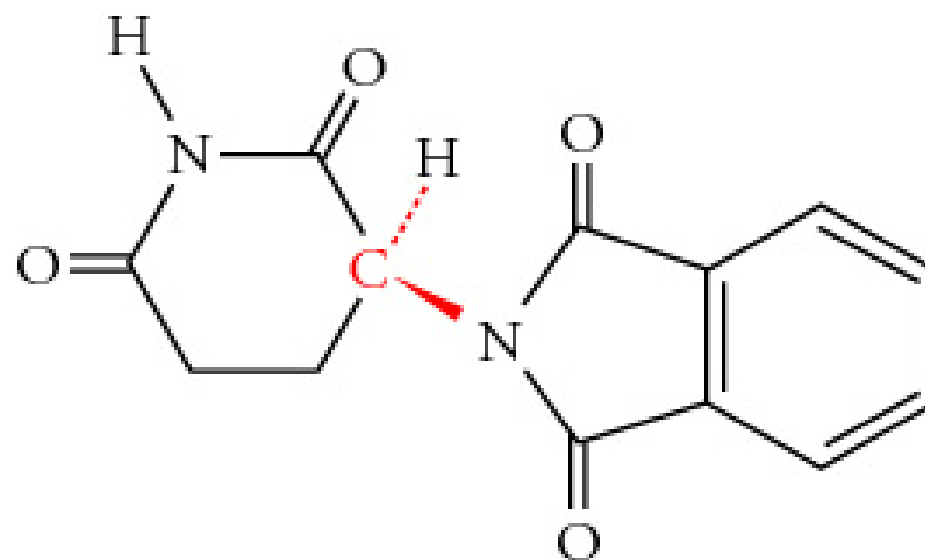
(b)



(c)



Ibuprofen



Thalidomide

