
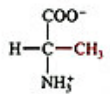
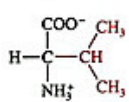
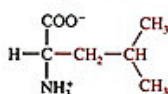
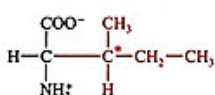
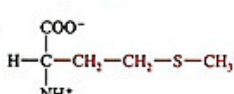
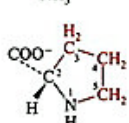
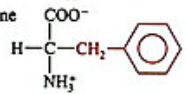
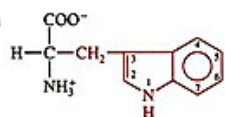


Name, Three-letter Symbol, and One-letter Symbol	Structural Formula ^a	Residue Mass (D) ^b	Average Occurrence in Proteins (%) ^c	pK ₁ α-COOH ^d	pK ₂ α-NH ₃ ⁺ ^d	pK _R Side chain ^d
Amino acids with nonpolar side chains						
Glycine Gly G		57.0	7.2	2.35	9.78	
Alanine Ala A		71.1	7.8	2.35	9.87	
Valine Val V		99.1	6.6	2.29	9.74	
Leucine Leu L		113.2	9.1	2.33	9.74	
Isoleucine Ile I		113.2	5.3	2.32	9.76	
Methionine Met M		131.2	2.2	2.13	9.28	
Proline Pro P		97.1	5.2	1.95	10.64	
Phenylalanine Phe F		147.2	3.9	2.20	9.31	
Tryptophan Trp W		186.2	1.4	2.46	9.41	

^a The ionic forms shown are those predominating at pH 7.0 although residue mass is given for the neutral compound. The C_α atoms, as well as those atoms marked with an asterisk, are chiral centers with configurations as indicated according to Fischer projection formulas. The standard organic numbering system is provided for heterocycles.

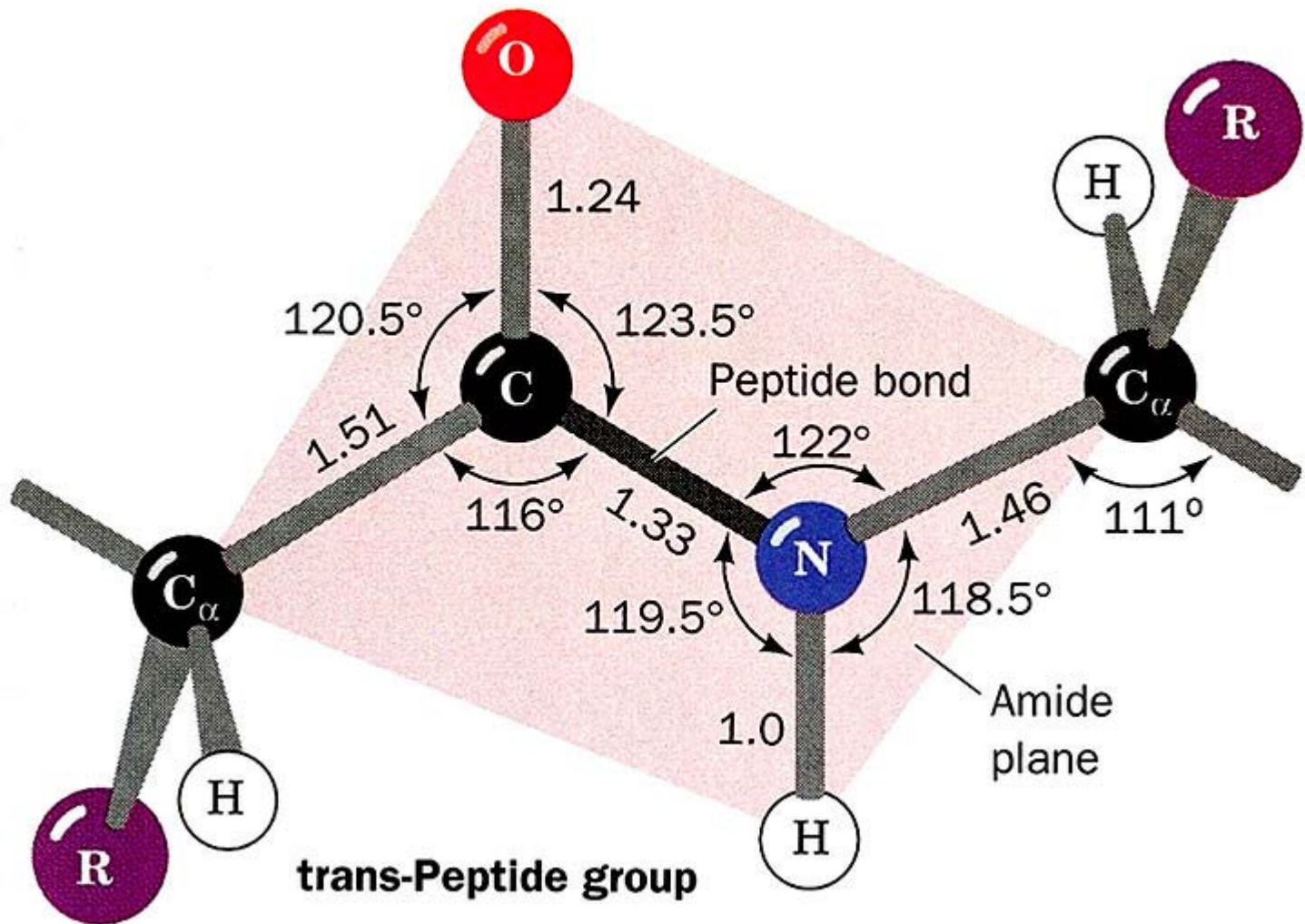
^b The residue masses are given for the neutral residues. For the molecular masses of the parent amino acids, add 18.0 D, the molecular mass of H₂O, to the residue masses. For side chain masses, subtract 56.0 D, the formula mass of a peptide group, from the residue masses.

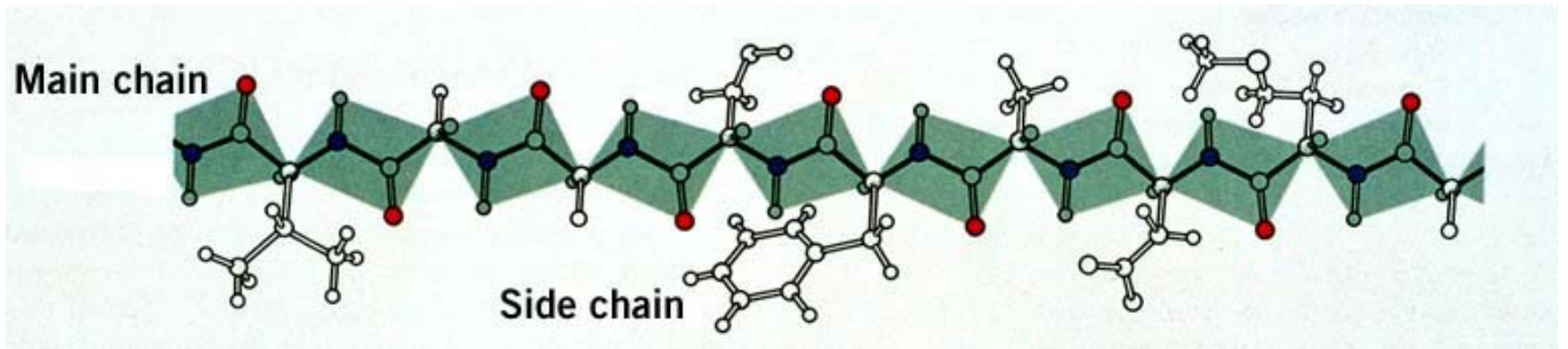
^c Calculated from a database of nonredundant proteins containing 300,688 residues as compiled by Doolittle, R. F. in Fasman, G. D. (Ed.), *Predictions of Protein Structure and the Principles of Protein Conformation*, Plenum Press (1989).

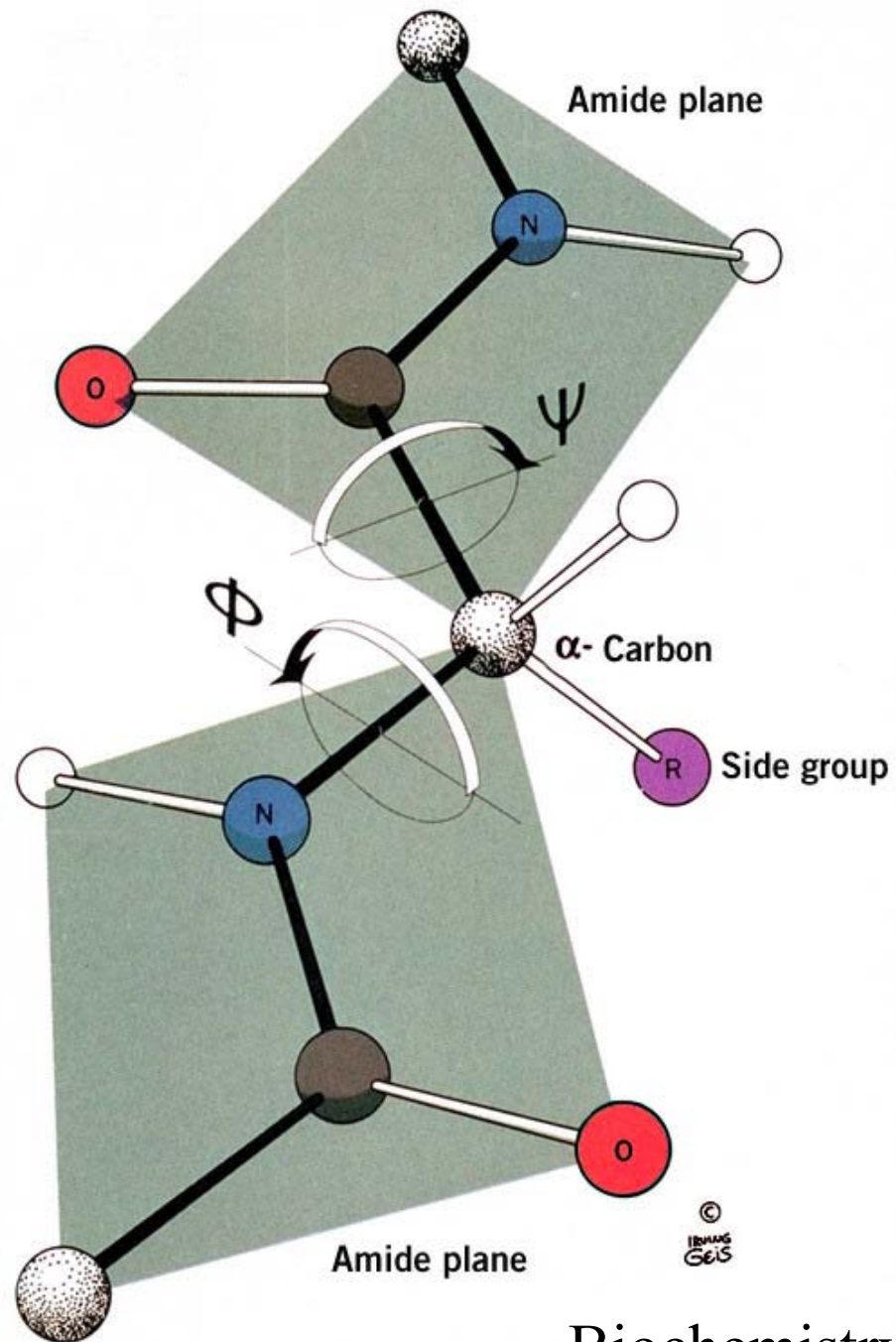
^d Source: Dawson, R.M.C., Elliott, D.C., Elliott, W.H. and Jones, K.M., *Data for Biochemical Research* (3rd ed.), pp. 1–31, Oxford Science Publications (1986).

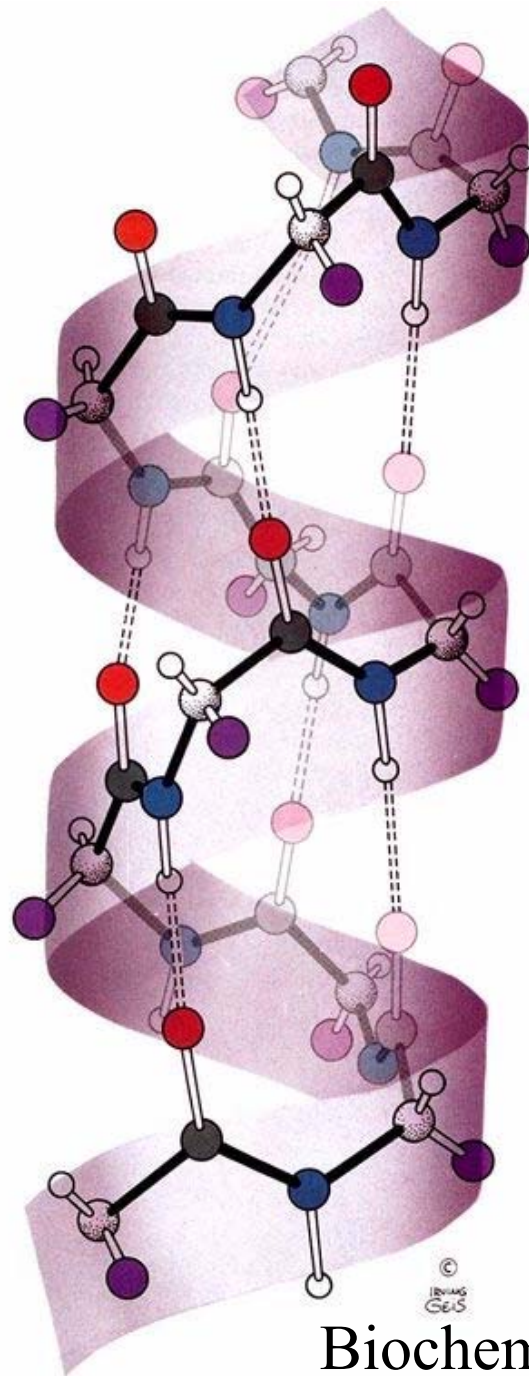
^e The three- and one-letter symbols for asparagine or aspartic acid are Asx and B, whereas for glutamine or glutamic acid they are Glx and Z. The one-letter symbol for an undetermined or "nonstandard" amino acid is X.

Name, Three-letter Symbol, and One-letter Symbol	Structural Formula ^a	Residue Mass (D) ^b	Average Occurrence in Proteins (%) ^c	pK ₁ α-COOH ^d	pK ₂ α-NH ₃ ⁺ ^d	pK _a Side chain ^d
<i>Amino acids with uncharged polar side chains</i>						
Serine Ser S		87.1	6.8	2.19	9.21	
Threonine Thr T		101.1	5.9	2.09	9.10	
Asparagine ^e Asn N		114.1	4.3	2.14	8.72	
Glutamine ^e Gln Q		128.1	4.3	2.17	9.13	
Tyrosine Tyr Y		163.2	3.2	2.20	9.21	10.46 (phenol)
Cysteine Cys C		103.1	1.9	1.92	10.70	8.37 (sulfhydryl)
<i>Amino acids with charged polar side chains</i>						
Lysine Lys K		128.2	5.9	2.16	9.06	10.54 (ε-NH ₃ ⁺)
Arginine Arg R		156.2	5.1	1.82	8.99	12.48 (guanidino)
Histidine His H		137.1	2.3	1.80	9.33	6.04 (imidazole)
Aspartic acid ^e Asp D		115.1	5.3	1.99	9.90	3.90 (β-COOH)
Glutamic acid ^e Glu E		129.1	6.3	2.10	9.47	4.07 (γ-COOH)



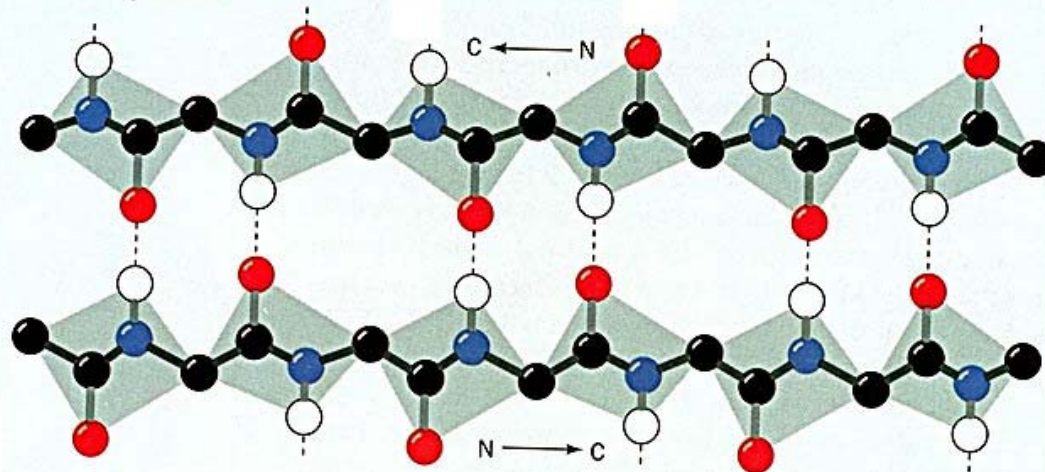




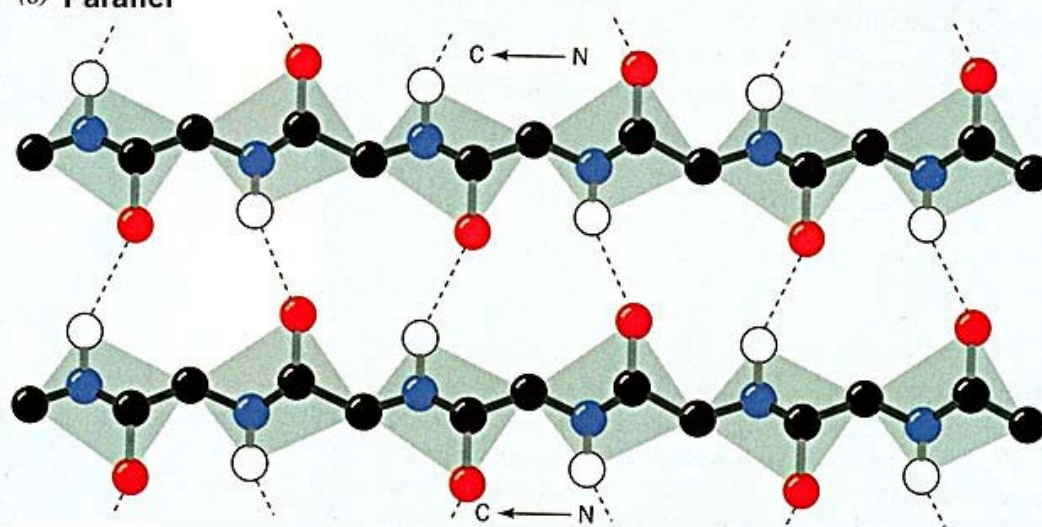


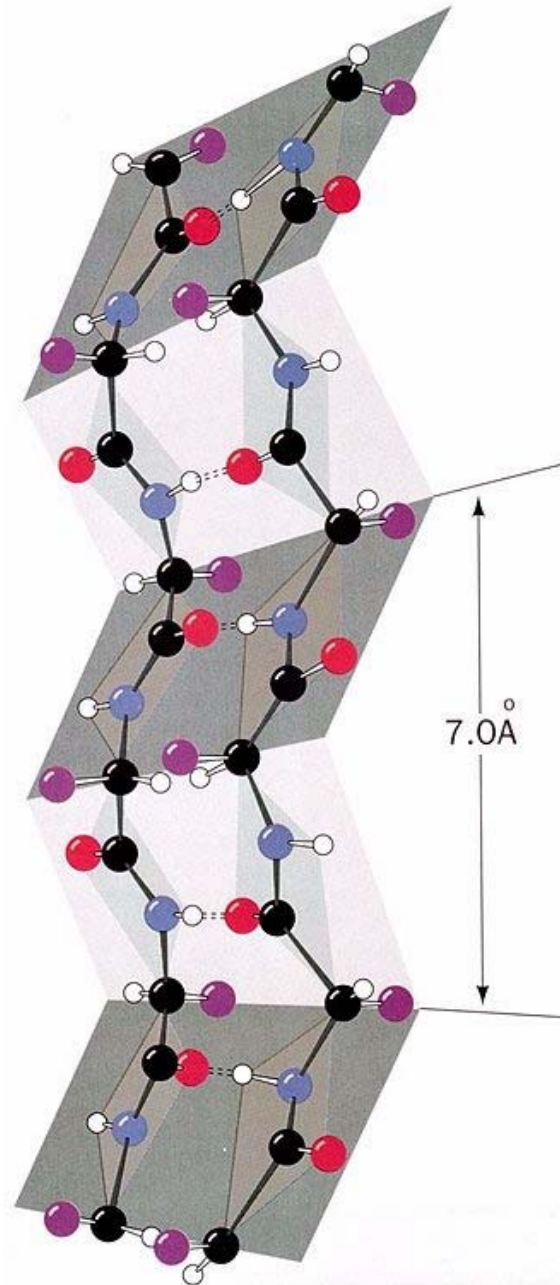
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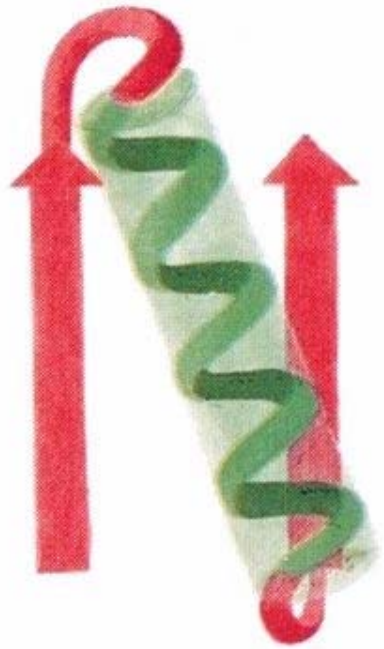
(a) Antiparallel



(b) Parallel







(a)



(b)



(c)