

Fig. 4-1 & 4-2:  $\alpha$ -amino acids

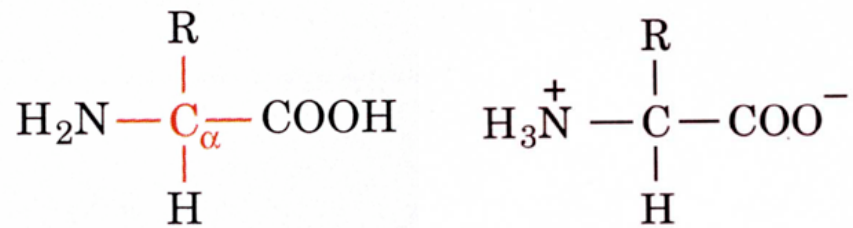
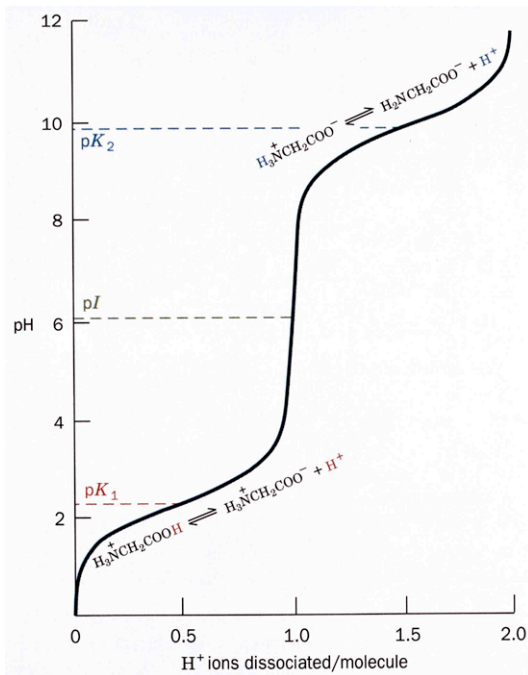


Fig. 4-8



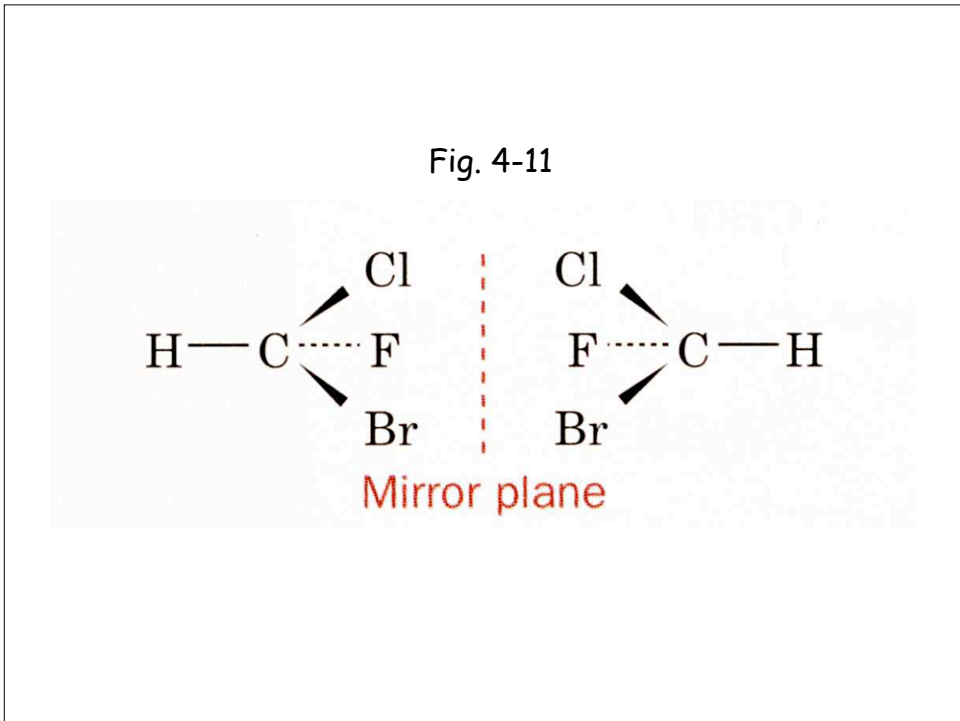
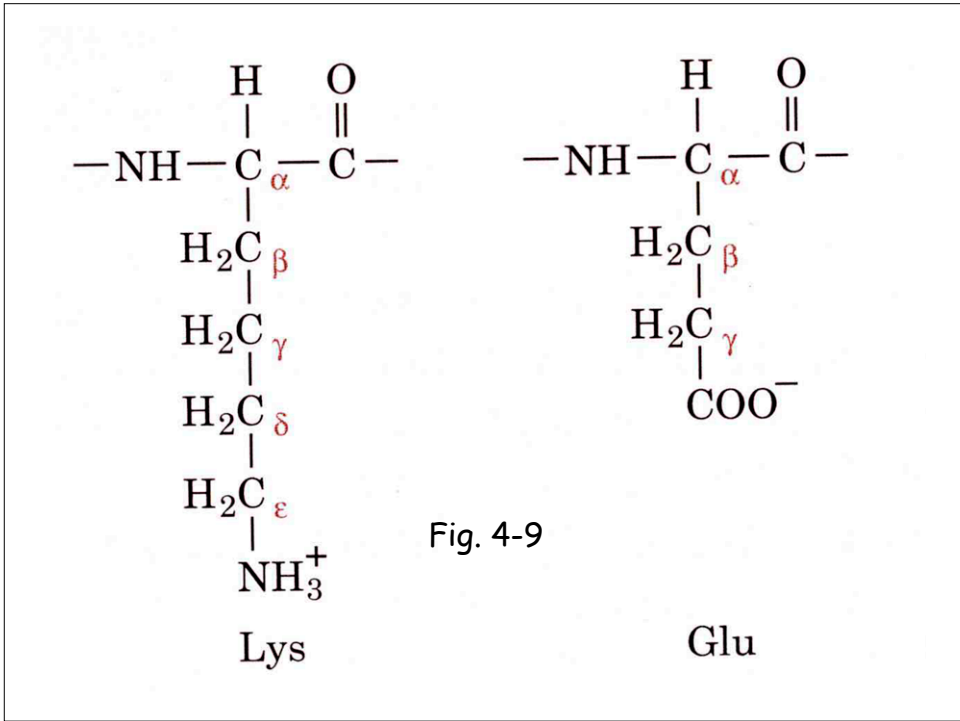
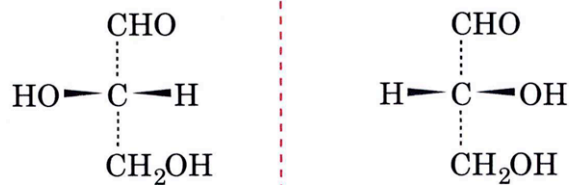
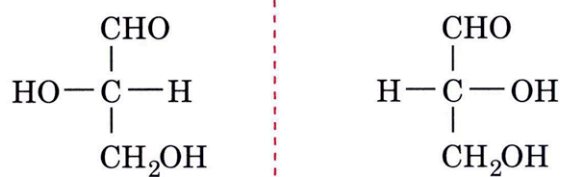


Fig. 4-12

Geometric formulas



Fischer projection

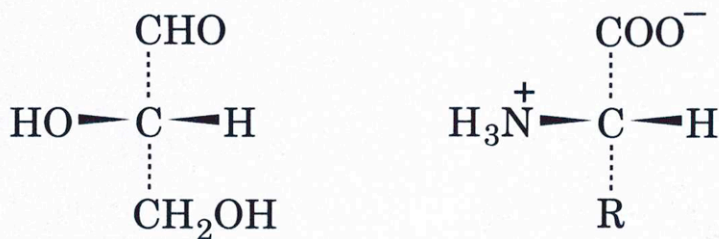


Mirror plane

**L-Glyceraldehyde**

**D-Glyceraldehyde**

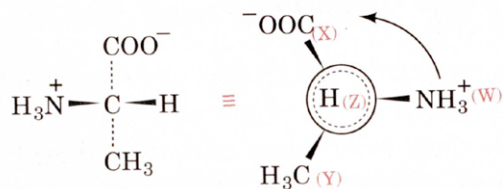
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**L-Glyceraldehyde**

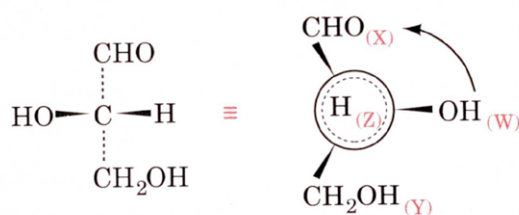
**L- $\alpha$ -Amino Acid**

### Box 4-1



L-Alanine

(S)-Alanine



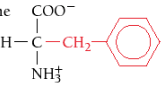
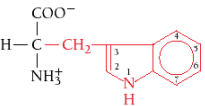
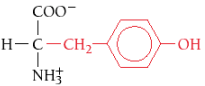
L-Glyceraldehyde

(S)-Glyceraldehyde

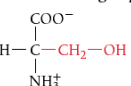
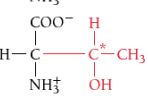
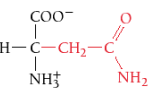
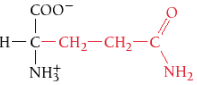
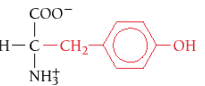
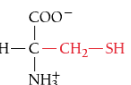
**Table 4-1. Key to Structure.** Covalent Structures and Abbreviations of the “Standard” Amino Acids of Proteins, Their Occurrence, and the pK Values of Their Ionizable Groups

Name, Three-letter Symbol, and One-letter Symbol	Structural Formula <sup>a</sup>	Residue Mass (D) <sup>b</sup>	Average Occurrence in Proteins (%) <sup>c</sup>	pK <sub>1</sub> α-COOH <sup>d</sup>	pK <sub>2</sub> α-NH <sub>3</sub> <sup>+</sup> <sup>d</sup>	pK <sub>R</sub> Side Chain <sup>d</sup>
<i>Amino acids with nonpolar side chains</i>						
<i>Aliphatic side chains</i>						
Glycine Gly G	$\begin{array}{c} \text{COO}^- \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{NH}_3^+ \end{array}$	57.0	7.2	2.35	9.78	
Alanine Ala A	$\begin{array}{c} \text{COO}^- \\   \\ \text{H}-\text{C}-\text{CH}_3 \\   \\ \text{NH}_3^+ \end{array}$	71.1	7.8	2.35	9.87	
Valine Val V	$\begin{array}{c} \text{COO}^- \\   \\ \text{H}-\text{C}-\text{CH} \\   \quad   \\ \text{NH}_3^+ \quad \text{CH}_3 \\ \quad \quad   \\ \quad \quad \text{CH}_3 \end{array}$	99.1	6.6	2.29	9.74	
Leucine Leu L	$\begin{array}{c} \text{COO}^- \\   \\ \text{H}-\text{C}-\text{CH}_2-\text{CH} \\   \quad \quad   \\ \text{NH}_3^+ \quad \quad \text{CH}_3 \\ \quad \quad \quad   \\ \quad \quad \quad \text{CH}_3 \end{array}$	113.2	9.1	2.33	9.74	
Isoleucine Ile I	$\begin{array}{c} \text{COO}^- \\   \\ \text{H}-\text{C}-\text{C}^*-\text{CH}_2-\text{CH}_3 \\   \quad \quad   \\ \text{NH}_3^+ \quad \quad \text{H} \end{array}$	113.2	5.3	2.32	9.76	
Methionine Met M	$\begin{array}{c} \text{COO}^- \\   \\ \text{H}-\text{C}-\text{CH}_2-\text{CH}_2-\text{S}-\text{CH}_3 \\   \\ \text{NH}_3^+ \end{array}$	131.2	2.2	2.13	9.28	
Proline Pro P	$\begin{array}{c} \text{H}_2 \\   \\ \text{COO}^- \\   \\ \text{C}^2 \\ / \quad \backslash \\ \text{H} \quad \text{N} \quad \text{CH}_2 \end{array}$	97.1	5.2	1.95	10.64	

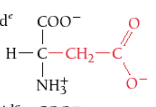
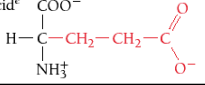
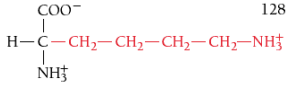
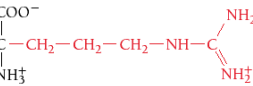
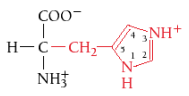
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<i>Amino acids with nonpolar side chains</i>						
<i>Aromatic side chains</i>						
Phenylalanine Phe F		147.2	3.9	2.20	9.31	
Tryptophan Trp W		186.2	1.4	2.46	9.41	
Tyrosine* Tyr Y		163.2	3.2	2.20	9.21	10.46 (phenol)
*Tyrosine is also considered to be hydrophilic, because of the phenolic -OH (see next slide) but is shown here, because it is aromatic and it's sidechain adsorbs UV light.						

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<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 <sup>e</sup> Asn N		114.1	4.3	2.14	8.72	
Glutamine <sup>e</sup> 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)

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<i>Amino acids with charged polar side chains</i>						
<b>Acidic</b>						
Aspartic acid <sup>e</sup> Asp D		115.1	5.3	1.99	9.90	3.90 (β-COOH)
Glutamic acid <sup>e</sup> Glu E		129.1	6.3	2.10	9.47	4.07 (γ-COOH)
<b>Basic</b>						
Lysine Lys K		128.2	5.9	2.16	9.06	10.54 (ε-NH <sub>3</sub> <sup>+</sup> )
Arginine Arg R		156.2	5.1	1.82	8.99	12.48 (guanidino)
Histidine <sup>f</sup> His H		137.1	2.3	1.80	9.33	6.04 (imidazole)

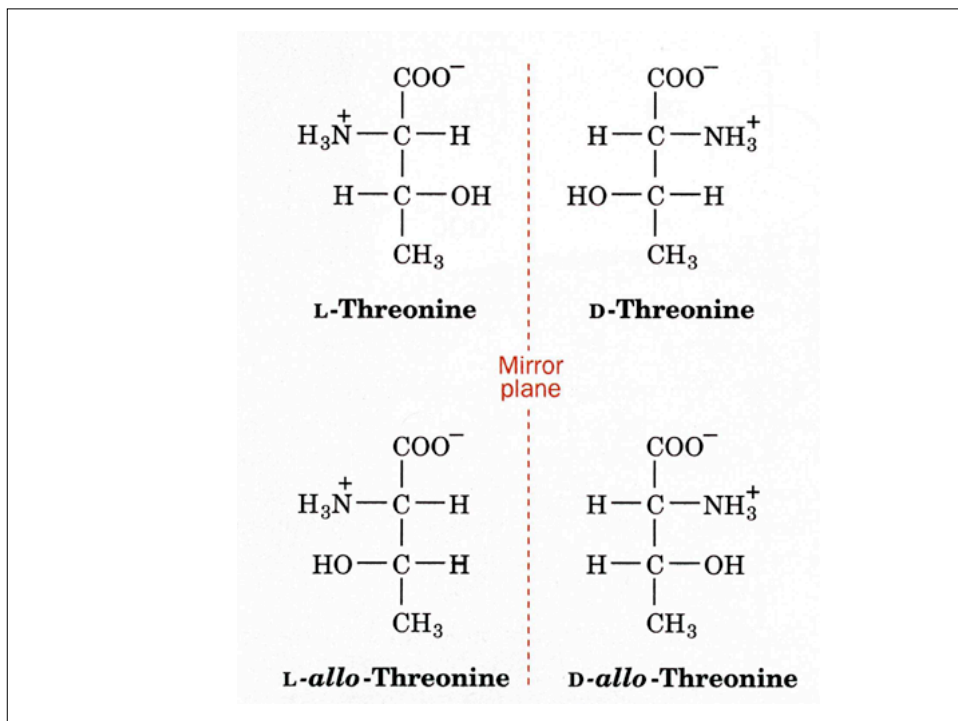




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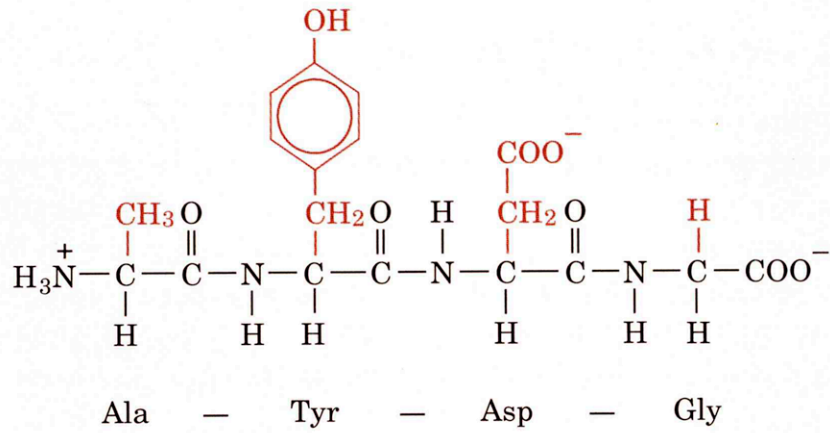


Fig. 4-6

