Table 1.1 The 20 classical amino acids

Amino acid	1-letter abbreviation	3-letter abbreviation
Amino acids with charged side group		
Glutamic acid	E	Glu
Aspartic acid	D	Asp
Lysine	K	Lys
Histidine	H	His
Arginine	R	Arg
Asparagine	N	Asn
Glutamine	Q	Gln
Amino acids with lipophilic (hydrophobic) side chain		
Phenylalanine	F	Phe
Tyrosine	Y	Tyr
Leucine	L	Leu
Isoleucine	I	Ileu
Valine	V	Val
Tryptophan	W	Trp
Amino acid with hydroxyl group		
Serine	S	Ser
Threonine	T	Thr
Amino acids with sulfur atom		
Cysteine	C	Cys
Methionine	M	Met
Other amino acids		
Glycine	G	Gly
Alanine	A	Ala
Proline	P	Pro

(50,51). The following concerns in vivo stability. Stability of proteins can also be compromised by degradation catalyzed by contaminating proteases and by the related issue of aggregation (52,53,54). Polyethylene glycol can be connected to recombinant enzymes and cytokines to enhance stability and lifetime of the drug in the bloodstream. Polypeptide drugs that are modified in this way are called pegylated polypeptides

[50] Paranandi MV, Guzzetta AW, Hancock WS, Aswad DW. Deamidation and isoaspartate formation during in vitro aging of recombinant tissue plasminogen activator. *J Biol Chem*. 1994;269:243–253.

[51] Aswad DW, Paranandi MV, Schurter BT. Isoaspartate in peptides and proteins: formation, significance, and analysis. *J Pharm Biomed Anal*. 2000;21:1129–1136.

[52] Simpson RJ. Stabilization of proteins for storage. *Cold Spring Harb Protocol*. 2010 May (5).

[53] O'Fágáin C. Storage and lyophilisation of pure proteins. *Methods Mol Biol*. 2011;681:179–202.

[54] Chi EY, Krishnan S, Randolph TW, Carpenter JF. Physical stability of proteins in aqueous solution: mechanism and driving forces in nonnative protein aggregation. *Pharm Res*. 2003;20:1325–1336.