As an example of an antibody drug, the amino acid sequence of the light chain and the amino acid sequence of the heavy chain of trastuzumab are shown below (54).

The amino acid sequence of the light chain of trastuzumab, as found at the cited accession numbers (55,56), is shown below. The light chain, shown below, has 214 amino acids.

```
   DIQMTQSPSSLSASVGDRVTITCRASQDVNT
AVAWYQQKPGKAPKLLIYSASFLYSGVPSRFSGS
RSGTDFTLTISSLQPEDFATYYCQQHYTTPPTFG
QGTKVEIKRTVAAPSFIFPPSDEQLKSGTASVVC
LLNNFYPREAKVQWKVDNALQSGNSQESVTEQDS
KDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLS
SPVTKSFNRGEC
```

The amino acid sequence of the heavy chain of this antibody, which has 451 amino acids and can be found at the cited accession number (57), is shown below.

```
   EVQLVESGGGLVQPGGSLRLSCAASGFNIKD
TYIHWVRQAPGKGLEWVARIYPTNGYTRYADSVK
GRFTISADTSKNTAYLQMNSLRAEDTAVYYCSRW
GGDGFYAMDYWGQGTLVTVSSASTKGPSVFPLA
PSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL
TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQT
YICNVNHKPSNTKVDKKVEPPKSCDKTHTCPPCP
APELLGGPSVFLFPPKPKDTLMISRTPEVTCVVV
DVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNS
TYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPI
EKTISKAKGQPREPQVYTLPPSRDELTKNQVSLT
CLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDS
DGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHN
HYTQKSLSLSPGK
```

The three-dimensional structure of this antibody drug can be found at: www.drugbank.ca/drugs/DB00072

Let us dwell on the structure of the light chain and heavy chain for a moment. In testing and marketing any polypeptide drug, pharmaceutical companies are concerned with the following drug stability issues. First, it is the case that long-term storage of polypeptides results in the spontaneous deamination of residues of glutamine (Q) and asparagine (N). Deamination can occur at various steps in the manufacturing process, during shipment, and during storage. Also, oxidation of cysteine (C) residues can occur during manufacturing, shipping, and storage. These types of damage may lower the potency of polypeptide drugs. The reader will be able to find the locations of Q, N, and C, in the polypeptide chains of trastuzumab.

III. THE 20 CLASSICAL AMINO ACIDS

This reviews the 20 classical amino acids (Table 1.1). Twenty *classical* amino acids exist, and these are listed, along with their abbreviations in Table 1.1. The *nonclassical* amino acids include homocysteine, selenocysteine (58), methionine sulfoxide, ornithine, gamma-carboxyglutamate (GLA) (59), phosphotyrosine, hydroxyproline (60), sarcosine, and betaine. A *protein* is a long polypeptide that is a linear

[54]Fong S, Hu Z. Therapeutic anti-HER2 antibody fusion polypeptides. U.S. Pat. Appl. Publ. 2009/0226466; 2009. September 10.

[55]Cho HS, Mason K, Ramyar KX, et al. GenBank Accession No. PDB:1N8Z_A (submitted November 21, 2002).

[56]http://www.drugbank.ca/drugs/DB00072

[57]Trastuzumab (DB00072) DrugBank Accession No. DB0072. Creation date June 13, 2005, updated June 2, 2009.

[58]Brody T. Nutritional biochemistry. 2nd ed. San Diego, CA: Academic Press; 1999. p. 21 and 825–7.

[59]Brody T, Suttie JW. Evidence for the glycoprotein nature of vitamin K-dependent carboxylase from rat liver. Biochim. Biophys. Acta 1987;923:1–7.

[60]Brody T. Nutritional biochemistry. 2nd ed. San Diego, CA: Academic Press; 1999. p. 21 and 619–23.