FIGURE 8 A scanning electron micrograph showing crystals of the amino acid glycine, one of the building blocks of proteins.

Arrangement of Amino Acids in Peptides and Proteins

Each peptide, polypeptide, or protein is made up of a special sequence of amino acids. A simple set of three-letter abbreviations is used to represent each amino acid in these kinds of molecules. For example, the dipeptide from glycine, shown in **Figure 8,** and glutamic acid would be written as Gly–Glu. The dipeptide Glu–Gly is an isomer of Gly–Glu. Both have the same numbers of C, H, O, and N atoms but in a different order. For the tripeptide Val–Asp–His, made up of valine, asparagine, and histidine, there are five isomers. There are 120 possible isomers for a pentapeptide of five different amino acids. Even though there are only 20 types of amino acids in proteins found in the human body, an incredibly large number of polypeptide and protein molecules are possible. Even for a small protein made up of 100 amino acids, the number of possible combinations of the 20 amino acids is 20^{100}! Polypeptide and protein function depend not only on the kinds and number of amino acids but also on their order. Later, you will see that even the difference of only one amino acid in a polypeptide or protein chain can cause a big change in a protein's activity in a cell.

Amino Acid Side-Chain Reactions

The properties of amino acids—and ultimately polypeptides and proteins—depend on the properties of the side chains present. For example, the side chain of *glutamic acid* is acidic, and the side chain of *histidine* is basic. The side chains of *asparagine* and several other amino acids are polar. In addition, both glutamic acid and asparagine can form hydrogen bonds, shown in **Figure 9.** Some amino acid side chains can form ionic or covalent bonds with other side chains. *Cysteine* is a unique amino acid, because the −SH group in cysteine can form a covalent bond with another cysteine side chain. **Figure 9** shows that two cysteine units—at different points on a protein molecule—can bond to form a *disulfide bridge*. Such bonding can link two separate polypeptides or can cause one long protein to bond onto itself to form a loop. In fact, curly hair is a result of the presence of many disulfide bridges in hair protein.

FIGURE 9 Three kinds of interactions between side chains on a polypeptide molecule are shown here. These interactions help determine the shape of a protein.