7.4: Proteins

Proteins are macromolecules that are composed of nitrogen, carbon, hydrogen, and oxygen along with smaller quantities of sulfur. The small molecules of which proteins are made are composed of 20 naturally occurring **amino acids**. The simplest of these, glycine, is shown in the first structure in Figure 7.4, along with two other amino acids. As shown in Figure 7.4, amino acids join together with the loss of a molecule of H_2O for each linkage formed. The three amino acids in Figure 7.4 are shown linked together as they would be in a protein in the bottom structure in the figure. Many hundreds of amino acid units may be present in a protein molecule.

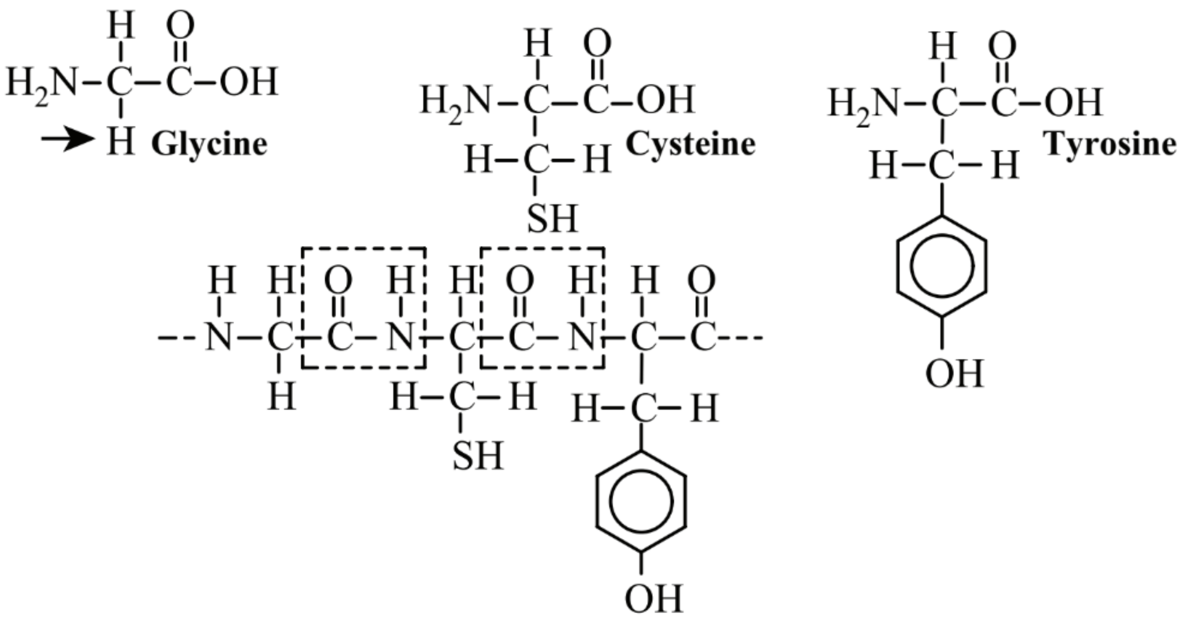

Figure 7.4. Three amino acids. Glycine is the simplest amino acid. All others have the basic glycine structure except that different groups are substituted for the H designated in glycine by an arrow. The lower structure shows these three amino acids linked together in a macromolecule chain composing a protein. For each linkage, one molecule of H_2O is lost. The peptide linkages holding amino acids together in proteins is outlined by a dashed rectangle.

The three-dimensional structures of protein molecules are of the utmost importance and largely determine what the proteins do in living systems and how they are recognized by other biomolecules. Enzymes, special proteins that act as catalysts to enable biochemical reactions to occur, recognize the substrates upon which they act by the complementary shapes of the enzyme molecules and substrate molecule. There are several levels of protein structure. The first of these is determined by the order of amino acids in the protein macromolecule. Folding of protein molecules and pairing of two different protein molecules further determine structure. The loss of protein structure, called **denaturation**, can be very damaging to proteins and to the organism in which they are contained.

Two major kinds of proteins are tough **fibrous proteins** that compose hair, tendons, muscles, feathers, and silk, and spherical or oblong-shaped **globular proteins**, such as hemoglobin in blood or the proteins that comprise enzymes. Proteins serve many functions. These include **nutrient proteins**, such as casein in milk, **structural proteins**, such as collagen in tendons, **contractile proteins**, such as those in muscle, and **regulatory proteins**, such as insulin, that regulate biochemical processes.

Proteins with carbohydrate groups attached constitute an important kind of biomolecule called **glycoproteins**. Collagen is a crucial glycoprotein that provides structural integrity to body parts. It is a major constituent of skin, bones, tendons, and cartilage.

Some proteins are very valuable biomaterials for pharmaceutical, nutritional, and other applications and their synthesis is an important aspect of green chemistry. The production of specific proteins has been greatly facilitated in recent years by the application of genetic engineering to transfer to bacteria the genes that direct the synthesis of specific proteins. The best example is insulin, a protein injected into diabetics to control blood sugar. Insulin injected for blood glucose control used to be isolated from the pancreas's of slaughtered cattle and hogs. Although this enabled many diabetics to live normal lives, the process of getting the insulin was cumbersome, supply was limited, and the insulin from this source was not exactly the same as that made in the human body, which often caused the body to have an allergic response to it as a foreign protein. The transfer through recombinant DNA technology of the human gene for insulin production into prolific *Escherichia coli* bacteria has enabled large-scale production of human insulin by the bacteria.
