# <u>Proteins perform most functions in cells</u>

### Objectives
List functions of proteins.
Describe the structure of amino acids and proteins.
Describe factors that influence protein shape.

### Key Terms
- <u>protein</u>
- <u>amino acid</u>
- <u>polypeptide</u>
- <u>denaturation</u>

The word *protein* comes from the Greek word meaning "first place." This term suggests the importance of this class of polymers. There are tens of thousands of different kinds of proteins. Each one has a unique, three-dimensional structure that corresponds to a specific function. This diversity enables proteins to provide the molecular tool kit for almost everything cells do.

### The Functions of Proteins
A <u>protein</u> is a polymer constructed from a set of just 20 kinds of monomers called amino acids. Proteins are responsible for almost all of the day-to-day functioning of organisms. For example, proteins form structures such as hair and fur, make up muscles, and provide long-term nutrient storage. Proteins with less-visible functions include proteins that circulate in the blood and defend the body from harmful microorganisms, and others that act as signals, conveying messages from one cell to another. Another group of proteins controls the chemical reactions in a cell. The structure of proteins is the key to understanding their elaborate and diverse functions.

### Amino Acids
Each <u>amino acid</u> monomer consists of a central carbon atom bonded to four partners (a carbon atom, remember, forms four covalent bonds). Three of the central carbon's partners are the same in all amino acids.

What is different about each type of amino acid is the "side group" that attaches to the fourth bond of the central carbon (Figure 5-12). The side group, sometimes called the "R-group," is responsible for the particular chemical properties of each amino acid. For example, the side group of the amino acid called leucine is a hydrocarbon (made of hydrogen and carbon). That region of leucine is hydrophobic. In contrast, the side group of the amino acid serine contains a hydroxyl group (-OH) that attracts water.

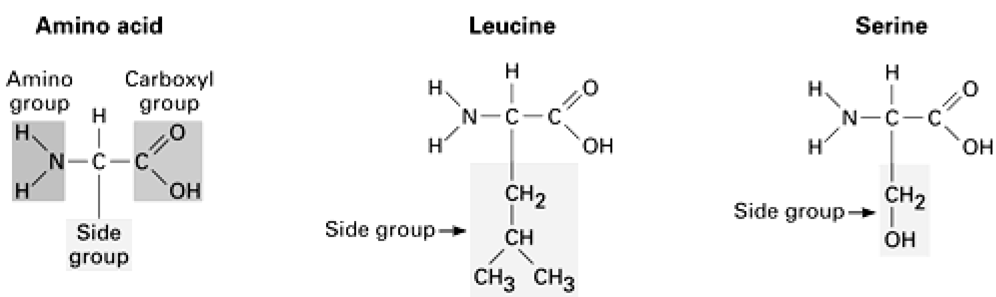


**Figure 5-12**
**All amino acids consist of a central carbon bonded to an amino group, a carboxyl group, and a hydrogen atom. The fourth bond is with a unique side group. The differences in side groups convey different properties to each amino acid.**

### Building a Protein
Cells create proteins by linking amino acids together into a chain called a <u>polypeptide</u>. Each link is created by a dehydration reaction that links one amino acid to the next in the chain. The bond formed between amino acids is called a peptide bond. Proteins are composed of one or more polypeptide chains.

Your body can make an enormous variety of proteins by arranging different amino acids in different orders. Think of how you can make thousands of different English words by using different combinations of 26 letters. Though the protein alphabet is slightly smaller, with just 20 "letters" (amino acids), the "words" are much longer. Most polypeptide chains are at least 100 amino acids in length. Because there are 20 choices for each amino acid in the chain, there is a very large number of possible amino acid sequences and therefore, a very large number of possible polypeptides. Just as each word in the English language is constructed from a unique sequence of letters, each protein has a unique sequence of amino acids (Figure 5-13).

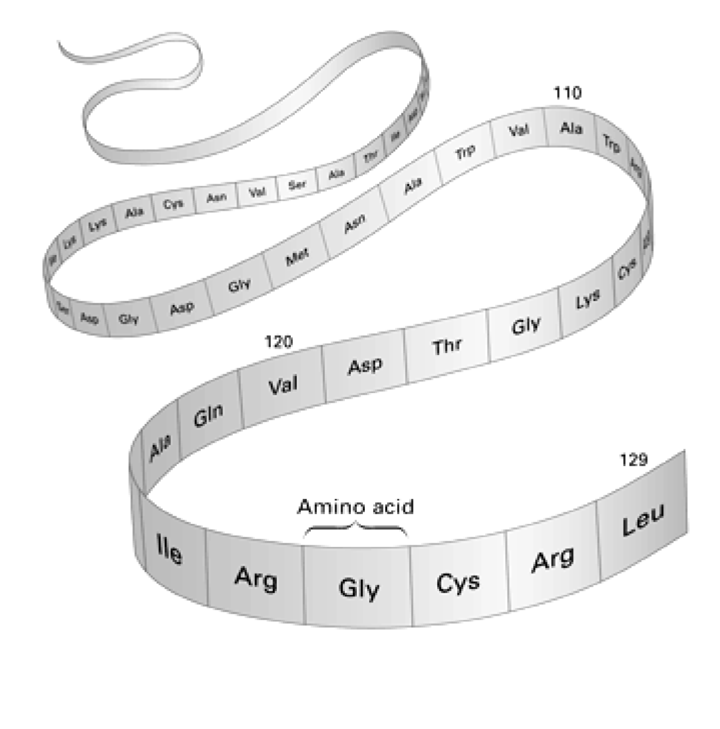


**Figure 5-13 The order of amino acids makes each polypeptide unique. There are 129 amino acids in this protein, called lysozyme. The three-letter symbols are abbreviations for the amino acid names.**

## Protein Shape

A protein in the simple form of amino acids linked together cannot function properly. You might compare this with the relationship between a long strand of yarn and a finished sweater. A functional sweater is not simply a bundle of yarn, but yarn that has been carefully knitted into a particular shape. Likewise, a functional protein consists of one or more polypeptides precisely twisted, folded, and coiled into a unique shape. But how does the protein fold in exactly the right way? The answer is not fully understood, but the sequence of amino acids is certainly important. For example, some side groups form bonds with each other. These forces help to fold a polypeptide and to keep it folded.

A protein's shape is also influenced by the surrounding environment, which is usually aqueous (water). Water attracts hydrophilic side groups and rejects hydrophobic ones. Therefore, hydrophilic amino acids tend to orient towards the outside edges of the protein, and hydrophobic amino acids cluster in the center of the protein.

An unfavorable change in temperature, pH, or some other quality of the environment can cause a protein to unravel and lose its normal shape. This process is called denaturation of the protein. You may have witnessed denaturation in action while frying an egg. The egg white changes from a clear liquid to a white solid during cooking because heat denatures the egg's proteins. The polypeptide chains become tangled up with one another. Heating unfolds proteins because most of the forces that maintain folding are weak attractions between pairs of side groups, and between side groups and water. Hot molecules collide with enough force to overcome these weak attractions. Since a protein's function depends on its shape, a protein that becomes denatured and loses its shape also loses its ability to work properly. Next, you will learn how this relationship of structure to function applies to proteins that perform as enzymes.