APPLICATION *Biochemistry*

Macromolecules

Large organic polymers are called macromolecules (the prefix *macro* means "large"). Macromolecules play important roles in living systems. Most macromolecules essential to life belong to four main classes, three of which we know as nutrients in food:

1. **Proteins** Hair, tendons, ligaments, and silk are made of protein. Other proteins act as hormones, transport substances throughout the body, and fight infections. Enzymes are proteins that control the body's chemical reactions. Proteins provide energy, yielding 17 kJ/g.
2. **Carbohydrates** Sugars, starches, and cellulose are carbohydrates. Carbohydrates are sources of energy, yielding 17 kJ/g.
3. **Lipids** Fats, oils, waxes, and steroids are lipids, nonpolar substances that do not dissolve in water. Fats are sources of energy, yielding 38 kJ/g.
4. **Nucleic acids** DNA and RNA are nucleic acids. In most organisms, DNA is used to store hereditary information and RNA helps to assemble proteins.

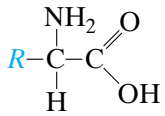
Proteins

Proteins are macromolecules formed by condensation reactions between amino acid monomers. Proteins contain carbon, oxygen, hydrogen, nitrogen, and usually some sulfur.

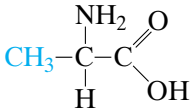
All amino acids have a carboxyl group, —COOH, and an amino group, —NH_2, attached to a central carbon atom, which is also attached to hydrogen, —H. Amino acids differ from one another at the fourth bond site of the central carbon, which is attached to a group of atoms (called an *R* group). *R* groups differ from one amino acid to another, as shown in the structures for several amino acids below. The proteins of all organisms contain a set of 20 common amino acids. The reaction that links amino acids is a condensation reaction, which is described in Chapter 22.

Each protein has its own unique sequence of amino acids. A complex organism has at least several thousand different proteins, each with a special structure and function. For instance, *insulin,* a hormone that helps the body regulate the level of sugar in the blood, is made up of two linked chains.

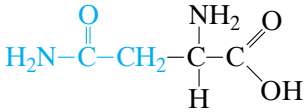
Amino acids have the same general structure. These examples show some of the variations within this class of compounds.



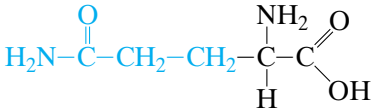
General structure



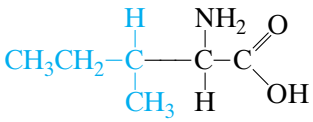
Alanine



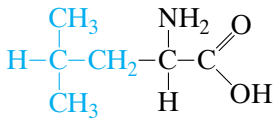
Asparagine



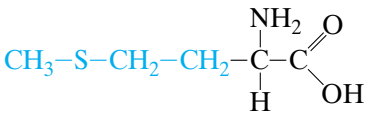
Glutamine



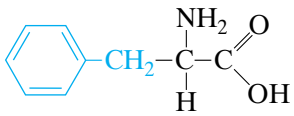
Isoleucine



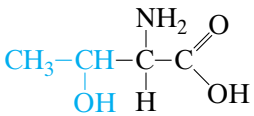
Leucine



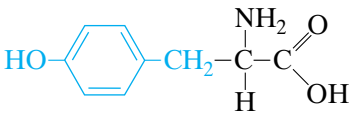
Methionine



Phenylalanine



Threonine



Tyrosine