

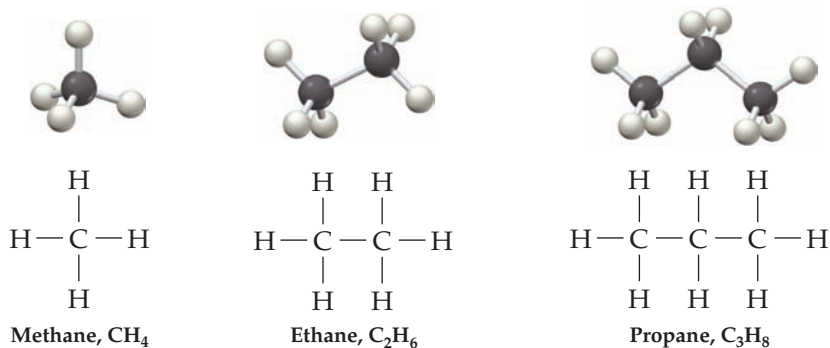
If the ultimate goal of chemistry is to understand the world around us on a molecular level, then a knowledge of **biochemistry**—the chemistry of living organisms—is a central part of that goal. Biochemistry, in turn, is a branch of *organic chemistry*, a term originally used to mean the study of compounds from living organisms while *inorganic chemistry* was used for the study of compounds from nonliving sources. Today, however, we know that there are no fundamental differences between organic and inorganic compounds; the same principles apply to both. The only common characteristic of compounds from living sources is that all contain the element carbon. Thus, **organic chemistry** is now defined as the study of carbon compounds.

But why is carbon special, and why do chemists still treat organic chemistry as a separate branch of science? The answers to these questions involve the ability of carbon atoms to bond together, forming long chains and rings. Of all the elements, only carbon is able to form such an immense array of compounds, from methane, with one carbon atom, to deoxyribonucleic acid (DNA), with tens of billions of carbon atoms. In fact, more than 67 million organic compounds have been made in laboratories around the world, and living organisms contain additional millions.

In this chapter, we will review key concepts of structure and bonding from Chapters 7 and 8 and apply them to organic compounds. We'll show how key features of molecular structure play an important role in the function of the major classes of biological molecules: carbohydrates, lipids, proteins, and nucleic acids.

## 23.1 ORGANIC MOLECULES AND THEIR STRUCTURES: CONSTITUTIONAL ISOMERS

Why are there so many organic compounds? The answer is that a relatively small number of atoms can bond together in a great many ways. Take molecules that contain only carbon and hydrogen—**hydrocarbons**—and have only single bonds. Such compounds belong to the family of organic molecules called **alkanes**. Because carbon atoms have four outer-shell electrons and form four covalent bonds (Section 7.5), the only possible one-carbon alkane is methane,  $\text{CH}_4$ . Similarly, the only possible two-carbon alkane is ethane,  $\text{C}_2\text{H}_6$ , and the only possible three-carbon alkane is propane,  $\text{C}_3\text{H}_8$ .



When larger numbers of carbons combine with hydrogen, however, more than one structure can result. There are two four-carbon alkanes with the formula  $\text{C}_4\text{H}_{10}$ , for instance. In one compound, the four carbons are in a row, while in the other they have a branched arrangement. Similarly, there are three alkanes with the formula  $\text{C}_5\text{H}_{12}$  and even more possibilities for larger alkanes. Compounds with all their carbons connected in a row are called **straight-chain alkanes**, and those with a branching connection of carbons are called **branched-chain alkanes**.

Compounds like the two different  $\text{C}_4\text{H}_{10}$  molecules and the three different  $\text{C}_5\text{H}_{12}$  molecules, which have the same molecular formula but different connections between atoms, are called **constitutional isomers**. For example, in butane, the second carbon from the left has bonds to two carbon atoms and two hydrogen atoms. In 2-methylpropane (a constitutional isomer), the second carbon atom has bonds to three carbon atoms and one

### REMEMBER . . .

**Isomers** are compounds that have the same formula but differ in the way their atoms are arranged. Constitutional isomers are compounds that have the same chemical formula but different connections between atoms. (Section 21.7)