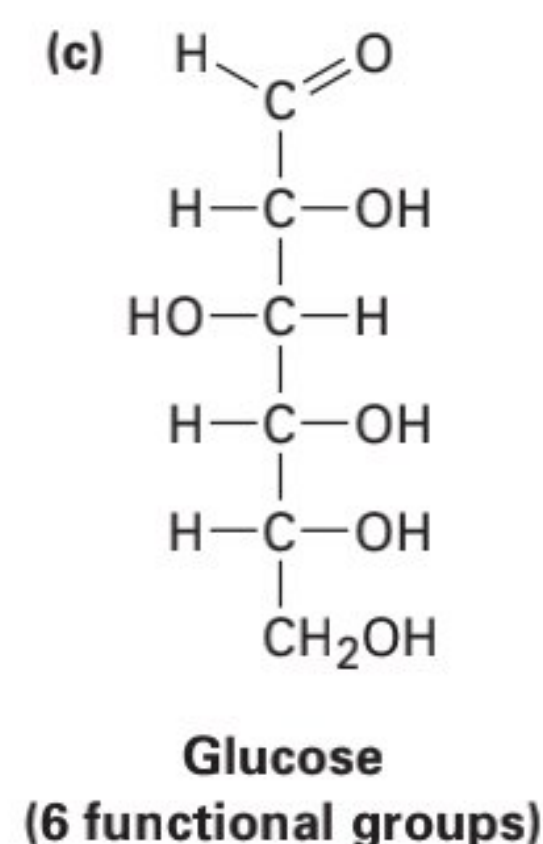
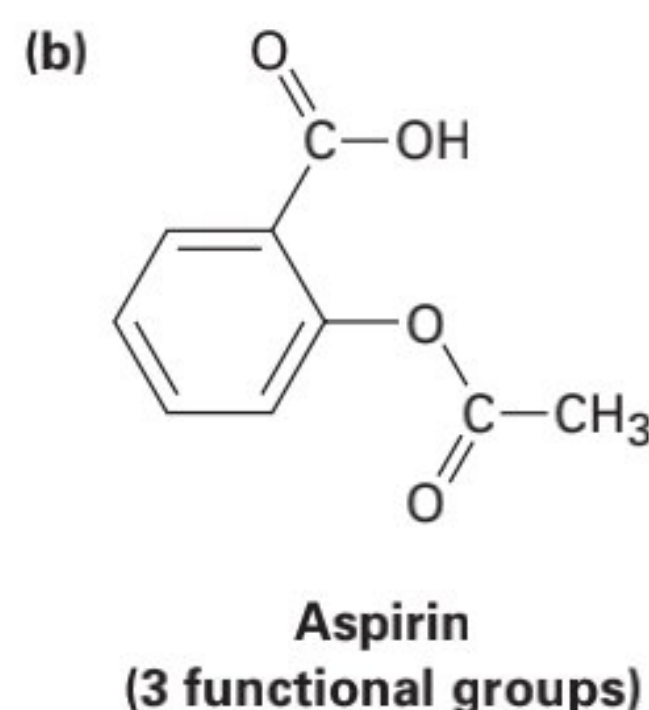
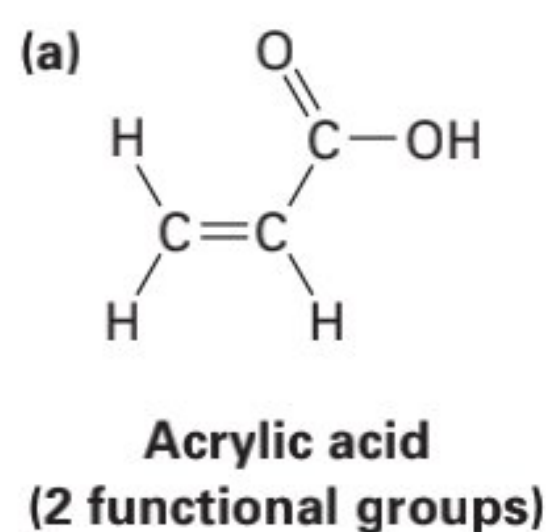


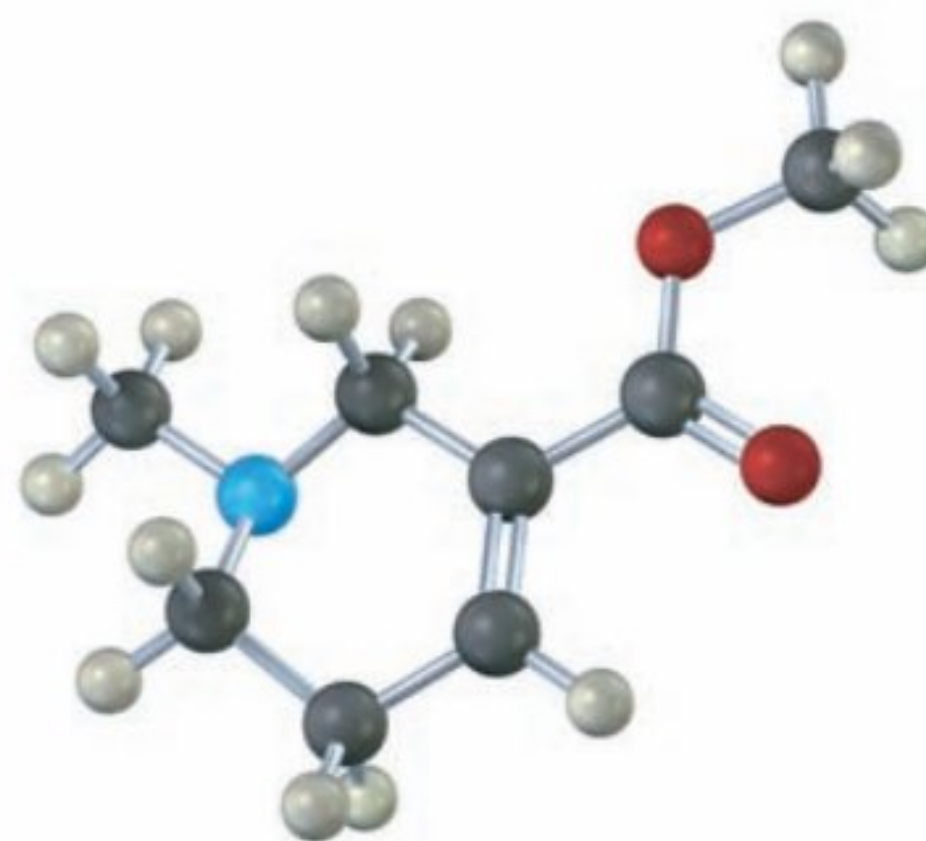
Problem 2.1 Identify the functional groups in the following molecules:



Problem 2.2 Propose structures for simple molecules that contain the following functional groups:

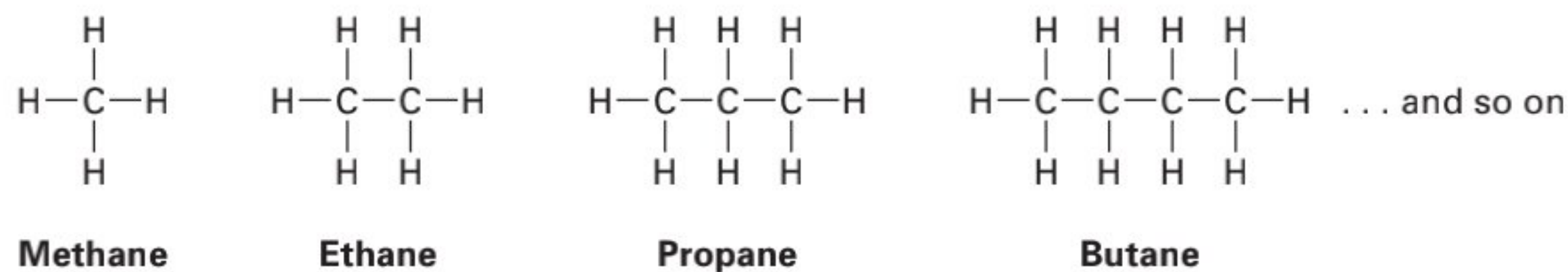
- (a) Alcohol (b) Aromatic ring (c) Carboxylic acid
 (d) Amine (e) Both ketone and amine (f) Two double bonds

Problem 2.3 Identify the functional groups in the following model of arecoline, a veterinary drug used to control worms in animals. Convert the drawing into a line-bond structure (gray = C, red = O, blue = N, ivory = H).

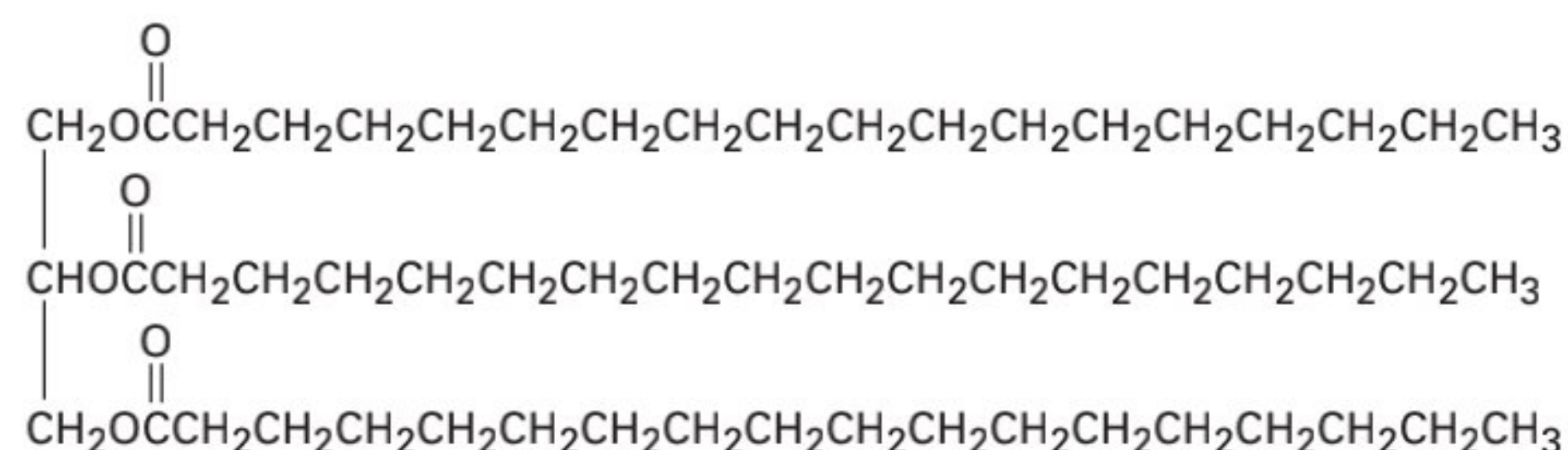


2.2 Alkanes and Alkyl Groups: Isomers

Before beginning a systematic study of the different functional groups, let's look first at the simplest family of molecules—the *alkanes*—to develop some general ideas that apply to all families. We saw in Section 1.7 that the C–C single bond in ethane results from σ (head-on) overlap of carbon sp^3 hybrid orbitals. If we imagine joining three, four, five, or even more carbon atoms by C–C single bonds, we generate the large family of molecules called **alkanes**.

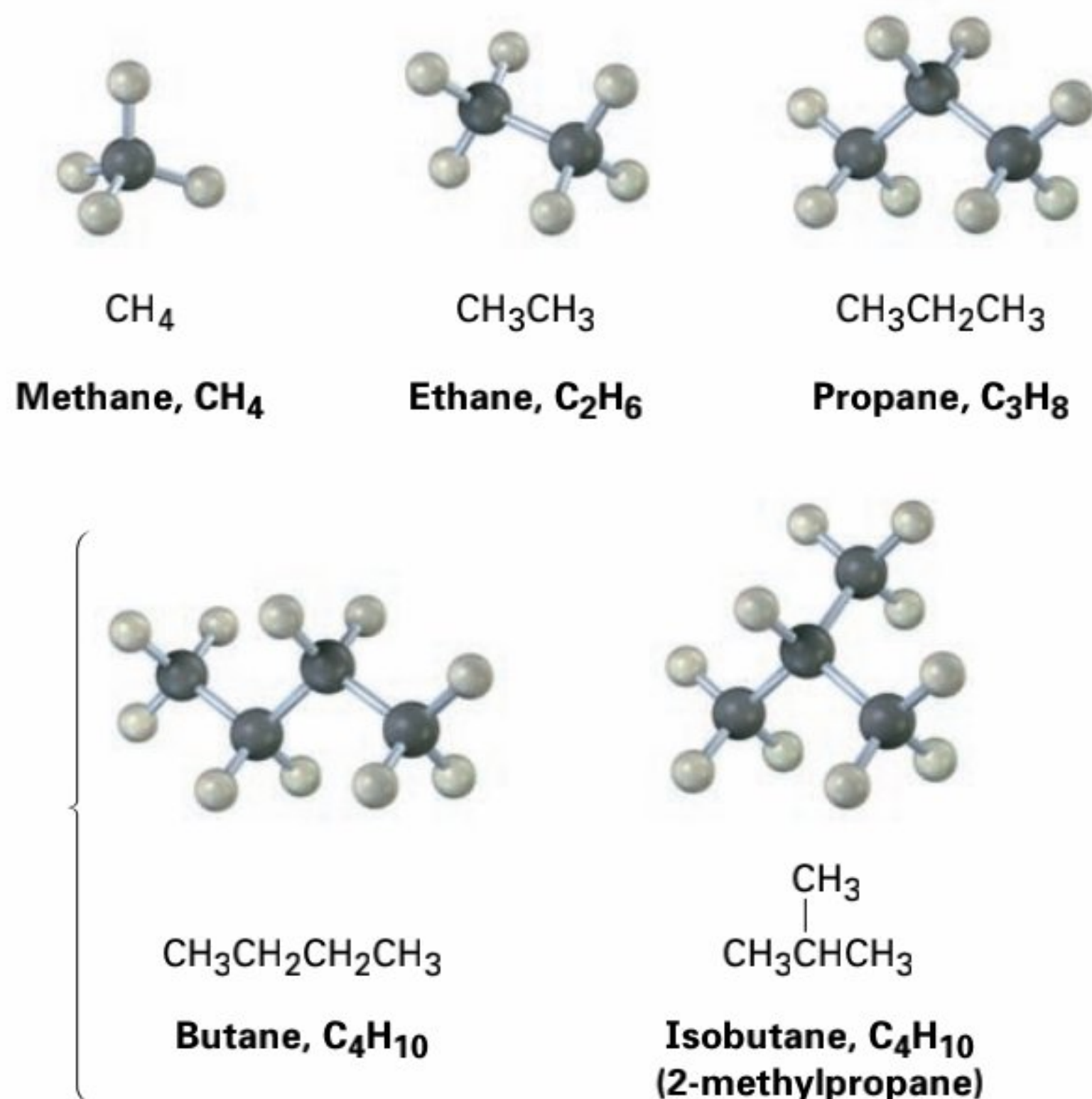


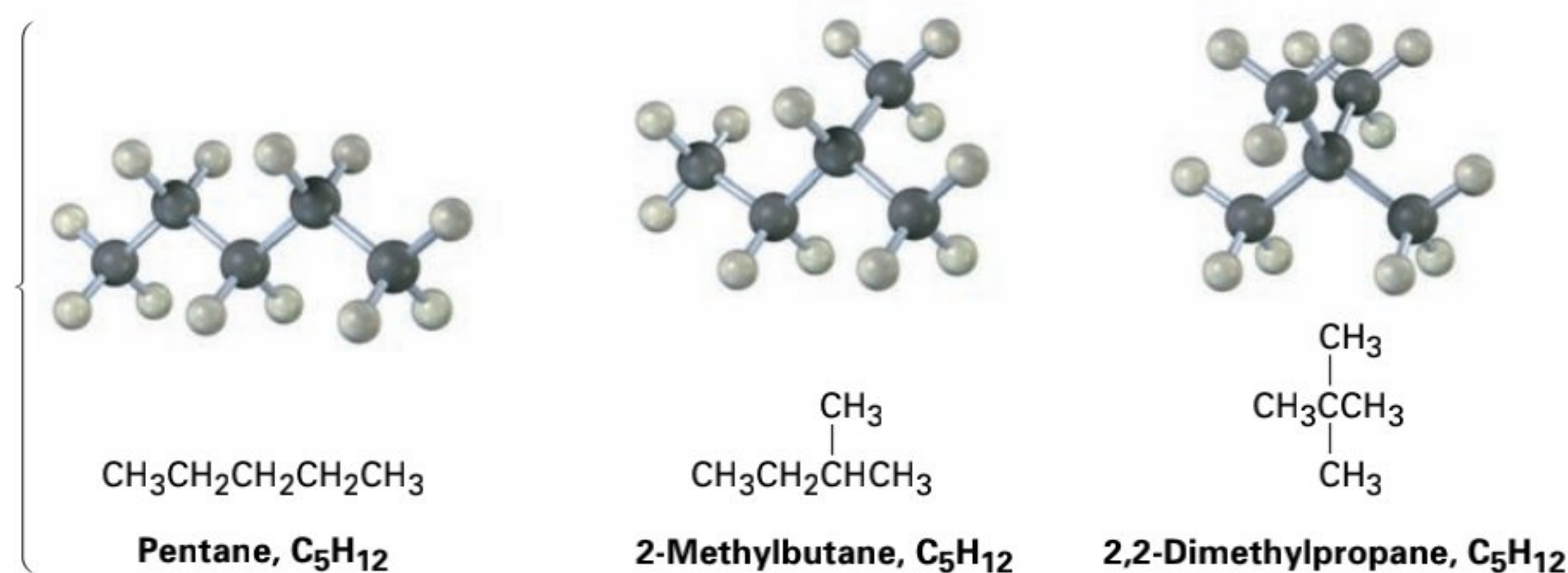
Alkanes are often described as *saturated hydrocarbons*: **hydrocarbons** because they contain only carbon and hydrogen atoms; **saturated** because they have only C–C and C–H single bonds and thus contain the maximum possible number of hydrogens per carbon. They have the general formula C_nH_{2n+2} , where n is any integer. Alkanes are also occasionally called **aliphatic** compounds, a word derived from the Greek *aleiphas*, meaning “fat.” We’ll see in Chapter 16 that animal fats contain long carbon chains similar to alkanes.



A typical animal fat

Think about the ways that carbon and hydrogen might combine to make alkanes. With one carbon and four hydrogens, only one structure is possible: methane, CH_4 . Similarly, there is only one possible combination of two carbons with six hydrogens (ethane, CH_3CH_3) and only one possible combination of three carbons with eight hydrogens (propane, $\text{CH}_3\text{CH}_2\text{CH}_3$). If larger numbers of carbons and hydrogens combine, however, more than one kind of molecule can form. For example, there are two ways that molecules with the formula C_4H_{10} can form: the four carbons can be in a row (butane), or they can branch (isobutane). Similarly, there are three ways in which C_5H_{12} molecules can form, and so on for larger alkanes.



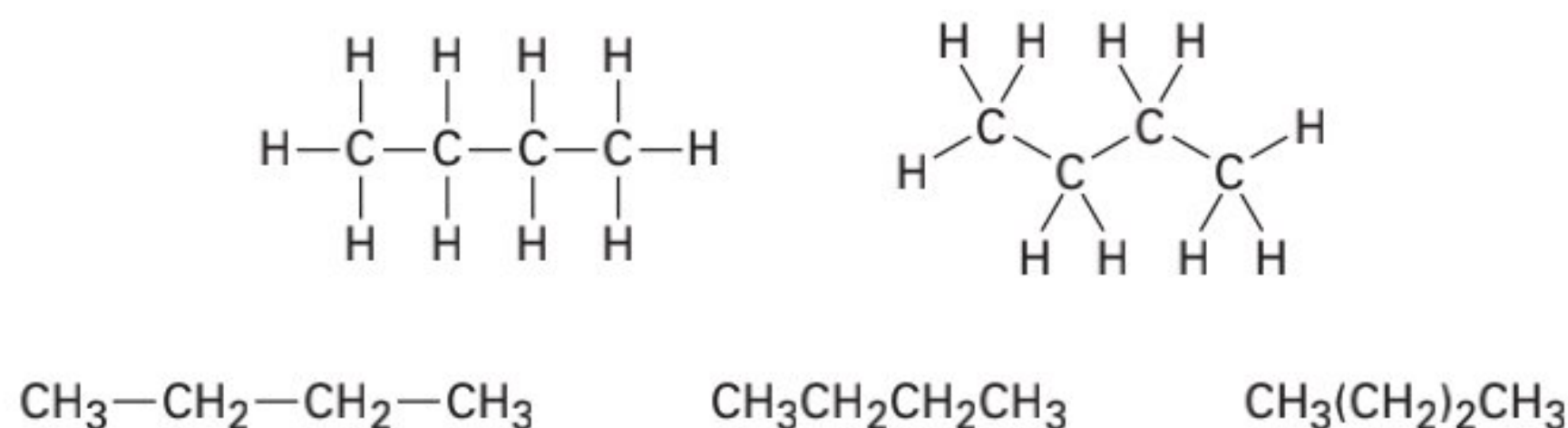


Compounds like butane, whose carbons are connected in a row, are called **straight-chain alkanes, or normal (*n*) alkanes**, whereas compounds with branched carbon chains, such as isobutane (2-methylpropane), are called **branched-chain alkanes**.

Compounds like the two C_4H_{10} molecules and the three C_5H_{12} molecules, which have the same formula but different structures, are called *isomers*, from the Greek *isos* + *meros*, meaning “made of the same parts.” **Isomers** have the same numbers and kinds of atoms but differ in the way the atoms are arranged. Compounds like butane and isobutane, whose atoms are connected differently, are called **constitutional isomers**. We’ll see shortly that other kinds of isomerism are also possible, even among compounds whose atoms are connected in the same order.

A given alkane can be arbitrarily drawn in many ways. The straight-chain, four-carbon alkane called butane, for instance, can be represented by any of the structures shown in Figure 2.2. These structures don’t imply any particular three-dimensional geometry for butane; they only indicate the connections among atoms. In practice, chemists rarely draw all the bonds in a molecule and usually refer to butane by the *condensed structure*, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ or $\text{CH}_3(\text{CH}_2)_2\text{CH}_3$. In such representations, the C–C and C–H bonds are “understood” rather than shown. If a carbon has three hydrogens bonded to it, we write CH_3 ; if a carbon has two hydrogens bonded to it, we write CH_2 , and so on. Still more simply, butane can even be represented as $n\text{-C}_4\text{H}_{10}$, where *n* signifies *normal*, straight-chain butane.

Figure 2.2 Some representations of butane ($n\text{-C}_4\text{H}_{10}$). The molecule is the same regardless of how it’s drawn. These structures imply only that butane has a continuous chain of four carbon atoms.



Straight-chain alkanes are named according to the number of carbon atoms they contain, as shown in Table 2.2. With the exception of the first four compounds—methane, ethane, propane, and butane—whose names have historical origins, the alkanes are named based on Greek numbers, according to the number of carbons. The suffix *-ane* is added to the end of each name to identify the molecule as an alkane. Thus, *pentane* is the five-carbon alkane, *hexane* is the six-carbon alkane, and so on.

If a hydrogen atom is removed from an alkane, the partial structure that remains is called an **alkyl group**. Alkyl groups are named by replacing the *-ane* ending of the parent alkane with an *-yl* ending. For example, removal of