13.1 Introducing Organic Compounds

Section Preview/ Specific Expectations

In this section, you will

- **identify** the origins and major sources of hydrocarbons and other organic compounds
- **communicate** your understanding of the following terms: *organic compound*, *hydrocarbons*, *petroleum*

As stated in the chapter opener, an organic compound is a molecular compound of carbon. There are a few exceptions to this definition, however. For example, scientists classify oxides of carbon, such as carbon dioxide and carbon monoxide, as *in*organic. However, the vast majority of carbon-containing compounds are organic.

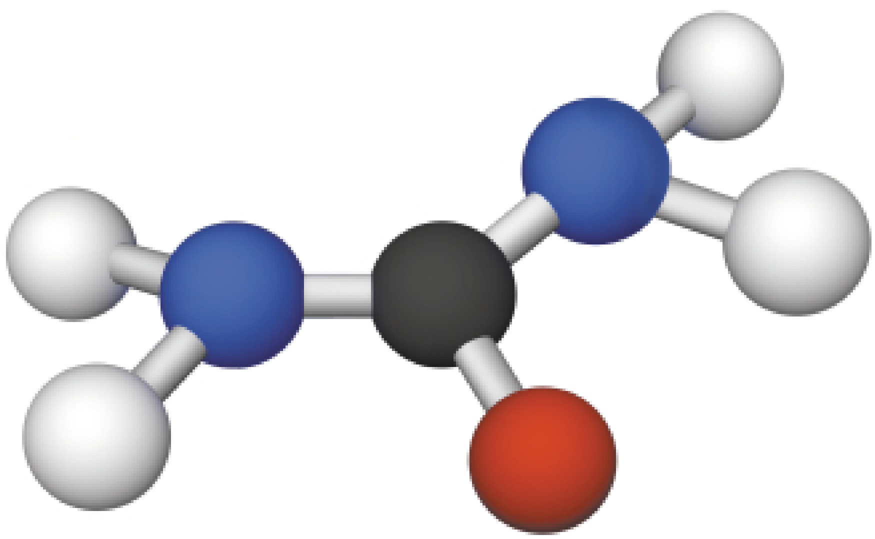
Organic Compounds: Natural and Synthetic

Organic compounds abound in the natural world. In fact, you probably ate sugar or starch at your last meal. Sugars, starches, and other carbohydrates are natural organic compounds. So are fats, proteins, and the enzymes that help you digest your food. Do you wear clothing made from wool, silk, or cotton? These are natural organic compounds, too. So are the molecules of DNA in the nuclei of your cells.

Until 1828, the only organic compounds on Earth were those that occur naturally. In that year, a German chemist named Friedrich Wohler synthesized urea—an organic compound found in mammal urine—from an inorganic compound, ammonium cyanate. (See Figure 13.1.) This was a startling achievement. Until then, chemists had assumed that only living or once-living organisms could be the source of organic compounds. They believed that living matter had an invisible "vital force." According to these early chemists, this vital (life) force made organic matter fundamentally different from inorganic (non-living) matter.

CHECKPOINT

Cyanides (containing carbon bonded to nitrogen, CN) and carbides, (such as calcium carbide, CaC_2) are compounds that contain carbon, but scientists classify them as inorganic. The same is true of carbonates, such as sodium hydrogen carbonate, $NaHCO_3$ (baking soda). Why are carbonate compounds inorganic, rather than organic, compounds?



Urea

Figure 13.1 **When Friedrich Wohler (1800–1882) synthesized urea, he wrote a letter to his teacher. In his letter, he said, "I must tell you that I can make urea without the use of kidneys…Ammonium cyanate is urea." About 20 years earlier, Wohler's teacher, Jons Jakob Berzelius (1779–1848), had invented the system that distinguishes organic substances from inorganic substances.**

Word LINK

Acetylsalicylic acid (ASA) was first produced commercially under the brand name Aspirin™ by Frederick Bayer and Company in 1897. The word "aspirin" comes from "a," for acetyl, and "spir," for spirea. *Spirea* is a genus of plants that is another natural source of salicylic acid.

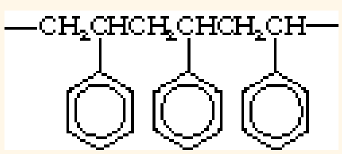
During the mid-1850s, chemists synthesized other organic compounds, such as methane and ethanol, from inorganic chemicals. Eventually chemists abandoned their vital-force ideas. We still use the terms "organic" and "inorganic," however, to distinguish carbon-based compounds from other compounds. For example, sugar is an organic compound since it is carbon based. Salt is inorganic since it contains no carbon.

During the last century, the number of synthetic (human-made) organic compounds has skyrocketed. Chemists invent more than 250 000 new synthetic organic chemicals *each year*. With almost endless variations in properties, chemists can synthesize organic compounds to make products as diverse as life-giving drugs, and toys. Nearly all medicines, such as painkillers, cough syrups, and antidepressants, are based on organic compounds. Perfumes, food flavourings, materials such as rubber and plastic, and fabrics such as nylon, rayon, and polyester are all organic compounds as well.

The next ExpressLab gives you a chance to make one such product. It is up to you to decide what purpose it could have.

ExpressLab Making Polymer Putty

Polymers are a fundamental part of your life. They also happen to be organic. *Polymers* are long molecular chains that are made up of smaller molecular units called monomers. Natural polymers include cellulose (the "fibre" in your food) and DNA. Synthetic polymers include plastics, polystyrene (see below), and the material you will produce in this activity.



Polystyrene is an example of a polymer.

Safety Precautions

Avoid inhaling the powdered borax. It may cause an allergic reaction. Wash your hands after working with the putty.

Procedure

1. Measure about 45 mL of white glue into a 250 mL beaker. Add an equal amount of warm water and a few drops of food colouring.
2. Measure 15 mL of solid borax into another 250 mL beaker. Add 60 mL of warm water. Stir for about 2 min. Note: You may find that not all of the solid borax dissolves. This is all right.
3. Pour 30 mL of the borax solution into the glue mixture. Then quickly and thoroughly stir the mixture.
4. Remove the material from the beaker, and "experiment" with it. Here are a few suggestions. Record your observations.
   - Hold the putty in one hand. Put your other hand below the putty, and let the putty slowly ooze into it.
   - Pull the putty apart slowly.
   - Pull the putty apart quickly.
   - Try bouncing the putty.
5. If time permits, you may wish to try changing the ratio of borax to glue to water. Test your results.
6. Dispose of any excess borax solution as directed by your teacher.

Analysis

1. Compare the properties of the starting materials with the properties of the product. Is the putty a solid or a liquid? Explain.
2. What practical applications for this product can you think of?

COURSE CHALLENGE

Why does society depend on fossil fuels? What are they used for? In the Course Challenge at the end of this book, you will investigate a different type of fossil fuel from an imaginary planet.

The Origins of Hydrocarbons and Other Organic Compounds

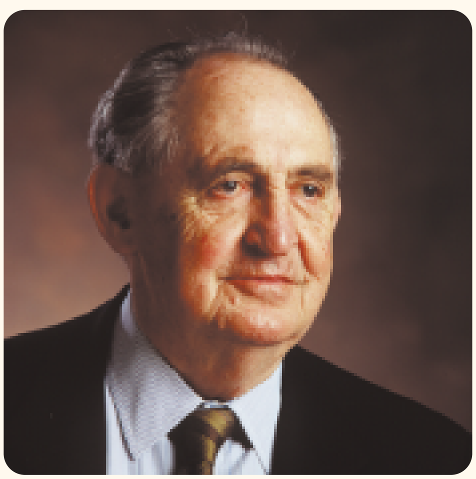
Most hydrocarbons and other organic compounds have their origins deep below Earth's present surface. In the past, as now, photosynthetic organisms used energy from the Sun to convert carbon dioxide and water into oxygen and carbohydrates, such as sugars, starches, and cellulose. When these organisms died, they settled to the bottom of lakes, rivers, and ocean beds, along with other organic matter. Bacterial activity removed most of the oxygen and nitrogen from the organic matter, leaving behind mainly hydrogen and carbon.

Over time, the organic matter was covered with layers of mud and sediments. As layer upon layer built up, heat and tremendous pressure transformed the sediments into shale and the organic matter into solid, liquid, and gaseous materials. These materials are the fossil fuels—coal, oil, and natural gas—that society depends on today. (See Figure 13.2.)

Canadians in Chemistry

Dr. Raymond Lemieux

Raymond Lemieux was born into a carpenter's family in 1920 at Lac La Biche, Alberta. He obtained a B.Sc. degree at the University of Alberta and a Ph.D. at McGill University in Montréal. Lemieux then worked briefly at Ohio State University, where he met Dr. Virginia McConaghie. They were married and soon moved to Saskatoon, Saskatchewan. There Lemieux became a senior researcher at a National Research Council (NRC) laboratory.



Raymond Lemieux (1920–2000)

In 1953, while at the NRC lab, Lemieux conquered what some have called "the Mount Everest of organic chemistry." He became the first person to completely synthesize sucrose, or table sugar. Sucrose is a carbohydrate with the chemical formula $C_{12}H_{22}O_{11}$. It is the main sugar in the sap of plants such as sugar beets and sugar cane. Sucrose is related to glucose, $C_6H_{12}O_6$, and other sugars.

Lemieux continued his research at the University of Ottawa, and then at the University of Alberta in Edmonton. He was especially interested in how molecules "recognize" each other and interact in the human body. For example, different blood groups, such as group A and group B, are determined by carbohydrate molecules that differ by only a single sugar. The body is able to recognize these specific sugars and adapt its response to foreign substances, such as bacteria and transplanted organs.

Since it was hard to obtain natural samples of the body sugars that Lemieux wanted to study, he found ways to synthesize them. This was groundbreaking research. Seeing the practical applications of his research, Lemieux was instrumental in starting several chemical companies. Today these companies make products such as antibiotics, blood-group determinants, and immunizing agents that are specific to various human blood groups. They also make complex carbohydrates that absorb antibodies from the blood in order to prevent organ transplant rejection.

Lemieux and his wife had six children and a number of grandchildren. With all that he had accomplished in life, Lemieux said, "My proudest achievement is my family." His autobiography, titled *Explorations with Sugar: How Sweet It Was*, was published in 1990.

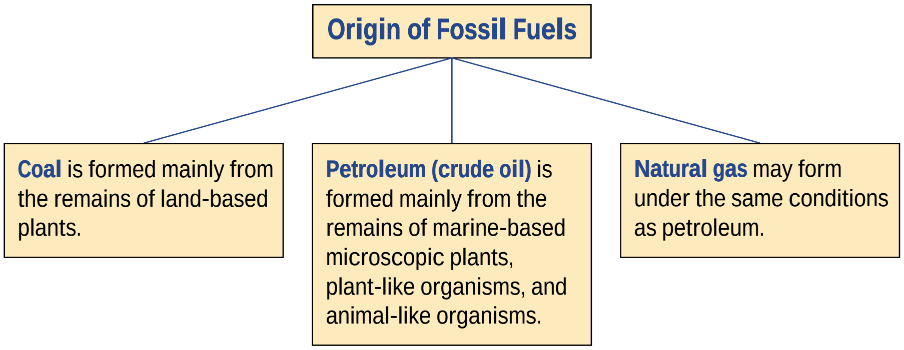


Figure 13.2 Ancient eras that had higher carbon dioxide concentrations, as well as warmer climates, gave rise to abundant plant and animal life on land and under water. Over time, as these organisms died, the organic substances that made up their bodies were chemically transformed into the materials known today as fossil fuels.

Sources of Hydrocarbons

Sources of hydrocarbons include wood, the products that result from the fermentation of plants, and fossil fuels. However, one fossil fuel—petroleum—is the main source of the hydrocarbons that are used for fuels and many other products, such as plastics and synthetic fabrics.

Petroleum, sometimes referred to as crude oil, is a complex mixture of solid, liquid, and gaseous hydrocarbons. To understand the importance of petroleum in our society, you need to become better acquainted with hydrocarbons. Your introduction begins, in the next section, with carbon—one of the most versatile elements on Earth.

Geology LINK

The origin of fossil fuels, depicted in Figure 13.2, is based on a theory called the *biogenic theory*. Most geologists accept this theory. A small minority of geologists have proposed an alternative theory, called the *abiogenic theory*. Use print and electronic resources to investigate the following:

- the main points of each theory, and the evidence used to support these points
- the reasons why one theory is favoured over the other

Record your findings in the form of a brief report. Include your own assessment of the two theories.

Section Review

1. **(a)** K/U Name three compounds that you know are organic.
   (b) K/U Name three compounds that you know are inorganic.
   (c) K/U Name three compounds that may be organic, but you do not know for sure.
2. K/U What are the origins of hydrocarbons and other organic compounds?
3. K/U Identify at least two sources of hydrocarbons and other organic compounds.
4. C Design a concept map (or another kind of graphic organizer) to show the meanings of the following terms and the relationships among them: organic compound, inorganic compound, hydrocarbon, fossil fuels, petroleum, natural gas.
5. K/U Copy the following compounds into your notebook. Identify each carbon as organic or inorganic, and give reasons for your answer. If you are not sure whether a compound is organic or inorganic, put a question mark beside it.

   (a) CH_4 **(c)** CO_2 **(e)** C_6H_6 **(g)** CH_3COOH
   (b) CH_3OH **(d)** HCN **(f)** NH_4SCN **(h)** $CaCO_3$