1.0: INTRODUCTION TO ORGANIC CHEMISTRY

OBJECTIVES

After completing this section, you should be able to

1. Define organic chemistry as the study of carbon-containing compounds.
2. Explain why the results of the experiments carried out by Chevreul and Wöhler contributed to the demise of the "vital force" theory.

KEY TERMS

Make certain that you can define, and use in context, the key term below.

- organic chemistry

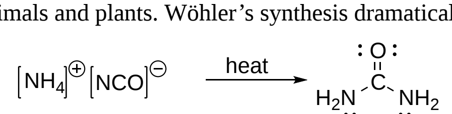
All living things on earth are formed mostly of carbon compounds. The prevalence of carbon compounds in living things has led to the epithet "carbon-based" life. The truth is we know of no other kind of life. Early chemists regarded substances isolated from *organisms* (plants and animals) as a different type of matter that could not be synthesized artificially, and these substances were thus known as *organic compounds*.

Figure 1.0.1: All organic compounds contain carbon and most are formed by living things, although they are also formed by geological and artificial processes. (credit left: modification of work by Jon Sullivan; credit left middle: modification of work by Deb Tremper; credit right middle: modification of work by "annszyp"/Wikimedia Commons; credit right: modification of work by George Shuklin)

Jöns Jacob Berzelius, a physician by trade, first coined the term "organic chemistry" in 1806 for the study of compounds derived from biological sources. Up through the early 19th century, naturalists and scientists observed critical differences between compounds that were derived from living things and those that were not.

Berzelius

In 1828, Friedrich Wöhler (widely regarded as a pioneer in organic chemistry) successfully completed an organic synthesis by heating ammonium cyanate and synthesizing of the biological compound urea (a component of urine in many animals) in what is now called "the Wöhler synthesis." Until this discovery it was widely believed by chemists that organic substances could only be formed under the influence of the "vital force" in the bodies of animals and plants. Wöhler's synthesis dramatically proved that view to be false.



ammonium cyanate **urea**

Urea synthesis was a critical discovery for biochemists because it showed that a compound known to be produced in nature only by biological organisms could be produced in a laboratory under controlled conditions from inanimate matter. This "in vitro" synthesis of organic matter disproved the common theory (vitalism) about the *vis vitalis*, a transcendent "life force" needed for producing organic compounds.

The ability to manipulate organic compounds includes fermentation to create wine and the making of soap, both of which have been a part of society so long their discovery has been lost in antiquity. Evidence has shown the Babylonians, as early as 2800 BC, were creating soap by mixing animal fat with wood ashes. It wasn't until the 19th century that the chemical nature of the creation of soap was discovered by Eugène Chevreul. In a reaction now call saponification, fats are heated in the presence of a strong base (KOH or NaOH) to produce fatty acid salts and glycerol. The fatty acid salts are the soap which improve water's ability to dissolve grease.

$$\text{animal fat} \xrightarrow[H_2O]{NaOH} \text{soap} + \text{glycerol}$$

Although originally defined as the chemistry of biological molecules, **organic chemistry** has since been redefined to refer specifically to carbon compounds — even those with non-biological origin. Some carbon molecules are not considered organic, with carbon dioxide being the most well known and most common inorganic carbon compound, but such molecules are the exception and not the rule. Organic chemistry focuses on carbon compounds and following movement of the electrons in carbon chains and rings, and also how electrons are shared with other carbon atoms and heteroatoms. Organic chemistry is primarily concerned with the properties of covalent bonds and non-metallic elements, though ions and metals do play critical roles in some reactions.

Why is carbon so special? The answer to this question involves carbon's special ability to bond with itself, which will be discussed in this chapter. Carbon is unique in its ability to form a wide variety of compounds from simple to complex. There are literally millions of organic compounds known to science from methane, which contains one carbon atom, to DNA which contains millions of carbons. More importantly, organic chemistry gives us the ability to make and alter the structure of organic compounds, which is the main topic in this book. The applications of organic chemistry are myriad, and include all sorts of plastics, dyes, flavorings, scents, detergents, explosives, fuels and many, many other products. Read the ingredient list for almost any kind of food that you eat — or even your shampoo bottle — and you will see the handiwork of organic chemists listed there.

The value to us of organic compounds ensures that organic chemistry is an important discipline within the general field of chemistry. In this chapter, we discuss why the element carbon gives rise to a vast number and variety of compounds, how those compounds are classified, and the role of organic compounds in representative biological and industrial settings. The field of organic chemistry is probably the most active and important field of chemistry at the moment, due to its extreme applicability to both biochemistry (especially in the pharmaceutical industry) and petrochemistry (especially in the energy industry). Organic chemistry has a relatively recent history, but it will have an enormously important future, affecting the lives of everyone around the world for many, many years to come