2.1: Chemistry is Good (and Unavoidable)

Chapter 1 has provided an overview of environmental science and sustainability in general. Sustainability is all about the way that we deal — often poorly and wastefully — with matter and energy. As the science of matter and how it interacts with energy, **chemistry** is a crucial science in sustainability. Most of this book is about the sustainable practice of chemistry.

Many people are freaked out by the idea of chemistry and try to avoid it. But avoiding chemistry is impossible. That is because all matter, all things, the air we must breathe, the water we must drink, and all living organisms are made of chemicals. People who try to avoid all things that they regard as chemical may fail to realize that chemical processes are continuously being carried out in their own bodies. These are processes that far surpass in complexity and variety those that occur in chemical manufacturing operations. So, even those people who want to do so cannot avoid chemistry; they are, themselves, complex chemical factories. The best course of action with anything that cannot be avoided and that might have an important influence on our lives (one's chemistry professor may come to mind) is to try to understand it, to deal with it. To gain an understanding of chemistry is probably one of the main reasons why you are reading this book.

As one of its major functions, this book seeks to present a body of chemical knowledge from the most fundamental level within a framework of the relationship of chemical science to human beings, their surroundings, and their environment. Face it, the study of chemistry-based upon facts about elements, atoms, compounds, molecules, chemical reactions, and other fundamental concepts needed to understand this science, though enticing to some, is found by many to be less than exciting. However, these concepts and many more are essential to a meaningful understanding of chemistry. Anyone interested in green chemistry clearly wants to know how chemistry influences people in the world around us. So this book discusses real-world chemistry, introducing chemical principles as needed.

During the approximately two centuries that chemical science has been practiced on an ever-increasing scale, it has enabled the production of a wide variety of goods that are valued by humans. These include such things as pharmaceuticals that have improved health and extended life, fertilizers that have greatly increased food productivity and prevented widespread starvation, and semiconductors that have made possible computers and other electronic devices. Without the persistent efforts of chemists and the enormous productivity of the chemical industry, nothing approaching the high standard of living enjoyed in modern industrialized societies would be possible.

But there can be no denying that in years past, and even at present, chemistry has been misused in many respects, such as the release of pollutants and toxic substances and the production of nonbiodegradable materials, resulting in harm to the environment and living things, including humans. It is now obvious that chemical science must be turned away from emphasis upon the exploitation of limited resources and the production of increasing amounts of products that ultimately end up as waste and toward the application of chemical science in ways that provide for human needs without damaging the Earth support system and depleting its natural capital (defined in Chapter 1) upon which all living things depend. Fortunately, the practice of chemical science and industry is moving steadily in the direction of environmental friendliness and resource sustainability. The practice of chemistry in a manner that maximizes its benefits while eliminating or at least greatly reducing its adverse impacts has come to be known as green chemistry, the central theme of this book.

As will be seen in later chapters of this book, the practice of chemistry is divided into several main categories. Most elements other than carbon are involved with **inorganic chemistry**. Common examples of inorganic chemicals are water, salt (sodium chloride), air pollutant sulfur dioxide, and lime. Carbon occupies a special place in chemistry because it is so versatile in the kinds of chemical species (compounds) that it forms. Most of the tens of millions of known chemicals are substances based on carbon. These compounds are organic chemicals and addressed by the subject of organic **chemistry**. The unique chemistry of carbon is addressed specifically in Chapter 6, "The Wonderful World of Carbon: Organic Chemistry and Biochemicals." The underlying theory and physical phenomena that explain chemical processes are explained by physical **chemistry**. Living organisms carry out a vast variety of chemical processes that are important in green chemistry and environmental chemistry. The chemistry that living organisms perform is biochemistry, which is addressed specifically in Chapters 7, "Chemistry of Life andGreen Chemistry." It is always important to know the identities and quantities of various chemical species present in a system, including various environmental systems. Often, significant quantities of chemical species are very low, so sophisticated means must be available to detect and quantify such species. The branch of chemistry dealing with the determination of kinds and quantities of chemical species is analytical **chemistry**.

As the chemical industry developed and grew during the early and mid-1900s, most practitioners of chemistry remained unconcerned with and largely ignorant of the potential for harm — particularly damage to the outside environment — of their products and processes. Environmental chemistry was essentially unknown and certainly not practiced by most chemists. Incidents of pollution and environmental damage, which were many and severe, were commonly accepted as a cost of doing business or blamed upon the industrial or commercial sectors. The unfortunate attitude that prevailed is summarized in a quote from a standard book on industrial chemistry from 1954 (*American Chemical Industry—A History*, W. Haynes, Van Nostrand Publishers, 1954): “By sensible definition any by-product of a chemical operation for which there is no profitable use is a waste. The most convenient, least expensive way of disposing of said waste — up the chimney or down the river — is best."

Despite their potential to cause harm, nobody is more qualified to accept responsibility for environmental damage from chemical products or processes than are chemists who have the knowledge to understand how such harmful effects came about. As the detrimental effects of chemical manufacture and use became more obvious and severe, chemists were forced, often reluctantly, to deal with them. At present, enlightened chemists and chemical engineers do not view the practice of environmentally beneficial chemistry and manufacturing as a burden, but rather as an opportunity that challenges human imagination and ingenuity.
