



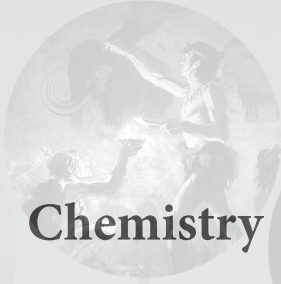
# CHEMISTRY

Our Past, Present, and Future

edited by Choon Ho Do | Attila E. Pavlath



**Chemistry**



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edited by

Choon Ho Do

Attila E. Pavlath



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## Preface

It is hard to imagine what our life would be without the numerous developments chemistry has provided in the past and is still providing for our everyday life. Just review our ordinary daily activities for a single day, from the moment we wake up to the time when we fall asleep. What would we do without toiletries, food, clothing, footwear, window glass, electric light, TV sets, telephones, etc.? All of these and much more are created by the wonders of chemistry. The list is very long and in their absence of chemical developments, we would be in the Stone Age.

Unfortunately, society is largely ignorant about the importance of chemistry. The discoveries of chemistry should be evident in various pieces of equipment frequently used every day; in materials that make our lives easier, more comfortable, and more pleasant; medications that ease pain and prevent and cure diseases, just to mention a few. Why is the general public unaware of all this? Are all of these advantages just taken for granted assuming that they just happen to be there? Apparently most people do not think about this. Why is it so difficult for the public to realize what life in our world would be like had chemistry not brought about those numerous discoveries? One does not have to be a scientist to be logical about this if these benefits are placed in the spotlight. Unfortunately, human nature is not perfect. It is a well-known fact that a catastrophe is more likely to capture the public's attention than a happy event. It is evident that the contributions of chemistry have to be publicized in plain language without any confusing chemical terms. That made us to realize the importance of this book as a means to enlighten anyone who picks it up.

Prof. Attila Pavlath, former president of the American Chemical Society and co-editor to this publication, was very much aware of the importance of public understanding of chemistry. During his presidency in 2001, his team launched a project titled "Technology Milestones from the Chemist's View" to disseminate the importance and application of chemistry in various fields to the public. The idea for the present book came from a paper by



co-editor Prof. Choon H. Do, former President of the Korean Chemical Society, titled “Public Understanding of Chemistry and Communication Programs” as presented at the 14th Asian Chemical Congress held in Bangkok, Thailand, in September 2011. Consequently, the publisher kindly supported the development of a book including this concept. We realized it is our job and responsibility to change the public’s perception of chemistry generally referred to as the Public Image of Chemistry. Hopefully, this book will enlighten the public and will support new chemical developments for a better future. The speed of the progressing of chemistry in connection with biology, physics, and engineering and its effects becomes faster and greater than ever before and will lead to better life for future generation.

The purpose of this book is to help its readers understand and appreciate chemistry, the discipline that builds the world, drives our lives, and keeps us healthy and safe. The book also aims to help the public realize that chemical knowledge is essential for the development of society and for the betterment of their lives now and in the future, too. The book also aims to help even a non-scientific person “think” or “consider” questions like “how,” “why,” and “what” one can do for a better life—through chemistry.

We designed this book to lead readers into a broad range of chemistry topics in three parts divided into 14 chapters: In the first part, the book describes the relationships among chemistry and the Universe, our body, health, and our history. In the second part, consisting of eight chapters, the book describes the contributions of chemistry to the enrichment of our present life, which were made possible through the effects of chemistry in the fields of agriculture, food, energy, medicine, health, transportation, and communication.. In the third part, the book describes activities for the image of chemistry, for our future, and for chemistry in Africa, where ancient developments need to be further clarified.

We tried to make this book a tool for readers to understand in clear, non-technical language the benefits of chemistry with the hope that the reader’s perception of chemistry would be based on correct information and not on media hype. Also, we have made an attempt to highlight the results of the discoveries rather than how chemists accomplished them. For example, we talk about the Haber-Bosch synthesis as the tool of making possible

artificial fertilizers that enabled us to feed the world, not necessarily describing in detail the experimental conditions for doing so.

We were very fortunate to be able to gather excellent chapter contributors for this book and we thank them for their contributions: Prof. Sunney Chan, Dr. Erika Godor, Dr. Dorottya Godor, Dr. Temechegn Engida, Prof. Young Ha Kim, Prof. Mary Virginia Orna, Prof. Veronika Németh, Prof. Livia Simon Sarkadi, Prof. James Wei, and Dr. Andrew Yeh.

We thank the Publishers and Directors, Mr. Stanford Chong and Ms. Jenny Rompas, for giving us the opportunity to produce this book and Mr. Arvind Kanswal for his team's professional editing.

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**Choon Ho Do**  
**Attila E. Pavlath**



# Introduction

**Choon Ho Do<sup>a</sup> and Attila E. Pavlath<sup>b</sup>**

<sup>a</sup>*President of the Korean Chemical Society, 2010*

<sup>b</sup>*President of the American Chemical Society, 2001*

Human beings are the results of a variety of chemical molecules and living by energies produced through chemical reactions of nutrients and oxygen in air and the use of materials, clothes, houses, cars, shoes, medicines, computers, TV, books, lightings, etc., made of chemical substances. We cannot be born, live, and survive without chemical reactions. The whole world is made of chemicals. The interactions of these chemicals are chemical reactions, and the study of the properties of these chemicals and reactions is chemistry.

Nevertheless, people do not think about these facts and are afraid of chemicals. They do not understand chemistry and chemicals correctly: They like pure water, clean air, medicines, perfumes and cosmetics, vitamins, and food supplements, but they are suspicious about or ignore fungicides, herbicides, artificial fertilizers, toxic substances, contaminants, etc. The materials we like and/or dislike are all chemicals.

Chemistry, as everything else in our life, is not perfect. There is always a risk, which may cause some problem. It may be an unexpected explosion in a chemical reaction or the release of a toxic material into our atmosphere. No action in our life has zero risk. We face many possible dangers from the day we are born. All medications, regardless of how beneficial they are, carry a risk clearly stated by the manufacturer by giving a long list of generally low but still more than zero probability of undesirable side effects. We accept those risks since we want the cure and we judge that the possible benefits outweigh the possible harmful side effects. To give an example, we pay little attention to the fact

that in the United States every day more than 80 persons (30,000 persons per year) die in automobile accidents. Nevertheless, everyone gets confidently into the car regularly balancing the benefits against the possible dangers.

Then why do many people become suddenly concerned about and even hostile toward chemistry when some shortcomings of chemistry are reported once in a while? It is logical to assume that because the rare accidents related to chemicals are frequently reported in large headlines and the numerous benefits of chemistry generally are ignored or at best relegated to a note on the fifteenth page, they skew our mind about the ratio of good and bad. Frequently, people have become more and more convinced that chemistry represents a danger in our life. Therefore, we need to understand chemistry and chemicals and the consequence of their interactions.

Why is it important? You might assume, especially if you are not involved in any chemistry-related activities, that it is of no concern to you and it makes no difference in your life. However, this is not true! If the public does not understand the benefit of chemistry, they will not support its practice. The end result is less chemical research and development, less number of new products, and less improvement on existing ones we use in our life. Chemical scientists understand the governing principles and properties of chemicals, and chemical reactions occur among chemicals. They know HOW it is done. However, the public must realize WHAT chemistry has done and what the consequences are if chemistry is downplayed and also realize the reasons why we need continuous developments in chemistry.

Why do we need fresh air? Why do we need clean water to drink? Why do we need healthy food? Why do we need gasoline to drive a car? What does gasoline do for the car? What will happen if we breathe bad gas? What will happen to our body if we drink polluted water? What gives color pictures on TV when it is switched on? These questions are related to chemicals and chemical reactions. Whether you believe it or not, whether you like it or not, our life is sustained by chemical reactions and chemicals. Why? It is because our body and our Universe are made up of chemicals. Living organisms and inorganic materials are chemicals. We cannot avoid chemicals and we cannot live without chemicals. Every day we need amenities essential to



our modern life, e.g., food, cloth, cars, housing, TV, smart phones. To produce these items, we have to produce more materials by better processes and in an economical way. All these are related to chemistry. We need chemicals and therefore it is necessary to understand chemistry for not only our existence sustenance but also improvement of our future.

The goal of this book is to show not just the important benefits of chemistry, but also reasons why chemistry is needed in the present time and in the future to solve problems ahead of us, whether you like it or not. Where and how to provide food for citizens to escape from hunger? How to get necessary energies for our living? How to develop medicines to cure diseases and healthy life? How to supply clean water to drink? What to do to prevent and reduce crimes? How to detect smuggling? How to detect fake items?

Sciences and technologies progress rapidly. So does society. You, as a human, whether you are a decision maker or an ordinary person, have to decide many things: not only scientific matters but also ethics for you and your family and society. That is why the public needs to understand chemistry to make a better choice or decision because most things and events are related to chemistry.

We hope that after reading this book, you will appreciate the benefits of chemistry. We also hope you will keep a proper balance between the benefits and problems in a rational and not sensationalist way. We have tried to make the book easily readable with joy and thoughtfulness. We hope this book will give you the tool to present the benefits of chemistry to your friends and neighbors in a simple non-scientific language and to help change their negative opinion about chemistry, too.

The book is composed of three parts consisting of 14 chapters. Following is a brief description of the parts and the chapters. Readers may start from any chapter because each chapter describes a different subject and is independent of each other.

**Part I. Chemistry Inherited from the Universe.** Images and perception on chemistry and comprehensive description are given for the need of understanding chemistry for our better future both personally and globally. This part is composed of the following three chapters.

**Chapter 1. Chemistry in the Universe, Our Body, and Our Life.** This chapter describes the chronological point of views of relationship between chemistry and the Universe, development of modern chemistry from alchemy, periodic table, chemical bonds, life, and biology. It also describes the relationship between biology and chemistry and the importance of the understanding of molecular biology for our future.

**Chapter 2. Chemistry in Human History.** Chemistry and the development of human history are discussed from philosophical and practical points of view. The chapter describes the ways in which humans took advantage of chemistry for their survival in their use of natural products, foods, materials, clothes, shelter, medicines, and communication.

**Chapter 3. Did Chemistry Change the World? YES,** chemistry did change our life from the world of cavemen to the modern world in terms of the development of materials. This chapter describes the developments related to wood, metals including copper, iron, aluminum, titanium, tungsten, lithium; bronze, plastics, leather, textile, glass, and ceramics.

**Part II. Contributions of Chemistry.** This part covers the every range of our life to realize how “chemistry made our present life possible” discussing the numerous achievements and effects of chemistry. The achievements of chemistry for human beings in the past are the basis of our present life and will be the driving force and lead to a better life in the future. The part is composed of the following eight chapters, from Chapter 4 to Chapter 11.

**Chapter 4. Agriculture:** Without chemistry helping the improvement of agricultural production by fertilizers and pesticides, supply of food, and benefits of new technologies, we would not have enough food for the ever-increasing population of the world. Chemistry also enhanced the flavor, appearance, and nutritional value of the food. It has also helped with livestock production, protection, and veterinary medical care.

**Chapter 5. Food: Supply and Health:** It is not enough to produce food. Chemistry’s health is essential for its preservation in healthy, safe, and affordable conditions. It continuously meets the challenges of agricultural productivity, water, healthy food, food safety, process efficiency, and supply chain waste.

**Chapter 6. Energy:** Energy is needed everywhere: in residence, commerce, and industry. Chemistry plays numerous roles in

providing energy for everything: the extraction and refining of fuels from nature, the processes in releasing energy, and the management of safety and the environment.

**Chapter 7. Medication: Diagnosis:** In addition to developing medicines, chemistry has helped doctors in diagnoses through clinical laboratories and various diagnostic instruments. History provides an insight into the development of the clinical application of chemistry and the development of X-ray, computer tomography, application of isotopes, positron emission tomography, and magnetic resonance imaging.

**Chapter 8. Medication: Curing:** Chemistry always had a major role in our health even before the development of novel pharmaceuticals, creation of new medical equipment, and refinement of diagnostic procedures for modern medicine. The development of pain management, inflammation management, psychotherapeutic agents, contraceptives, and a drug for diabetes, insulin, represents just a few examples.

**Chapter 9. Regenerative Medicine: Repairing Body:** Chemistry not only provides medicine to cure illness but also makes possible the development of artificial organs and biomaterials. This chapter discusses numerous examples such as artificial kidney, heart, and eye-lens. Regenerative medicine and tissue engineering are described, too. Cell therapy, bio-hybrid organs, bio-artificial liver, and artificial pancreas are a few examples of regenerative medicine.

**Chapter 10. Transportation:** To move from one place to another whether on foot or by some machine is based on chemistry, which contributed to transportation technology and left its stamp on the culture of human activities. The development of materials for vehicles, frames and wheels, fuels and engines, navigation system, including compass and GPS, building of roads using asphalt and concrete are the crucial factors.

**Chapter 11. Communication and Entertainment:** While communication might be thought as the result of physics, chemistry made the progress of electronic communication devices and storage devices possible. This chapter describes the role of chemistry in the development of cellular phones, electronics, fiberglass, paper, ink, recording sounds and pictures, copy machines, computers, and entertainment business, including movie films.

**Part III. Chemistry and Activities.** This part is composed of three chapters, from Chapter 12 to Chapter 14. It includes activities to improve the image of chemistry, roles of chemistry for the future, and activities in Africa.

**Chapter 12. Problems and Solutions: Activities of Chemists and Educators for the Public:** What is needed to understand chemistry and how can the public image of chemistry be improved? This chapter gives suggestions so the reader can help overcome sensationalist negative media publicity. Science teachers, chemists, and chemical engineers are urged to participate in the improvement of the image of chemistry and to create interest in science through science education.

**Chapter 13. What Can Chemistry Do for the Future:** While no one can accurately predict the future, this chapter discusses the possibilities in various areas such as artificial photosynthesis, new energy resources, materials, climate control, human life and health, human and Nature, change of desert, use of ocean and sea, and space travel. These topics are described in a systemic manner and not as individual chemical terms.

**Chapter 14. Chemistry in Africa: Progress and Application:** Chemistry is essential for progress in underdeveloped countries. This chapter lists methods and problems in chemical education. It discusses how various natural materials were used for health and agricultural purposes. Information is given on what type of research is being done to investigate needed materials for the special circumstances in those countries.