Afterword

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Once upon a time, some four and one-half billion or so years ago, the Earth was a dreadful, horrid place from what we can tell based upon various geological records. Cosmic debris from the formation of the solar system rained down nearly continuously on the Earth causing the oceans to boil, evaporate, and reform. Volcanoes spewed forth foul gases. The atmosphere was a noxious mix of nitrogen, ammonia, water vapor, methane, hydrogen sulfide, hydrogen cyanide, and carbon dioxide, with few traces of oxygen. In such a world nothing could live and nothing did. Then, something happened. Within a half billion years after the cosmic barrage had diminished, life sprang forth on Earth -- simple, one-celled life, but certainly life. For science, the question has always been, "How did life arise from nonlife?" This puzzle, which is central to our existence, remains to this day an unsolved great mystery.

The stage has been set, as can be understood by studying the present volume *Chemical Evolution. Chemical Change Across Space and Time.* We eagerly await the arrival of the players for the production of the next volume *Chemical Evolution: From Origins of Life to Modern Society.* What might we find in this second volume?

As the great chemist Isaac Asimov wrote in Omni (1983):

"We can make inspired guesses, but we don't know for certain what physical and chemical properties of the planet's crust, its ocean and its atmosphere made it so conducive to such a sudden appearance of life. We are not certain about the amount and forms of energy that permeated the environment in the planet's early days. Thus the problem that scientists face is how to explain the suddenness in which life appeared on this young (4.6 billion year old) planet earth. In the nineteenth century, scientists first began to accept the concept of biological evolution and to dismiss the possibility that life had been

In Chemical Evolution across Space & Time; Zaikowski, L., et al.;
ACS Symposium Series; American Chemical Society: Washington, DC, 2008.

created in its present complexity by some supernatural agency. That raised the question of how this extraordinary phenomenon called life could possibly have come to be by accident."

Are we any wiser today than then? It is my hope that the second volume will explore the age-old question about the origin or origins (?) of life. It is a huge question that has engaged the best minds for centuries, It is essentially a chemical question, worthy of the thoughts and efforts of all chemists.

To appreciate the complexity of the issue, just try to define what life is. If we content ourselves with simple definitions, like self-replicating, self-organizing, moving systems, we stumble into problems like whether the stars are alive or whether fire is alive. Surely we ought to do better than Dave Barry's definition: "Life is anything that dies when you stomp on it." Yet, this problem is not just a semantic one. To decide whether a virus is alive or not is a truly problematic inquiry, in my estimation. Of course, we can always have recourse to the same definition as for obscenity, namely, I know it when I see it. Still, despite this unsatisfying situation, chemists have a huge role to play in understanding how order can emerge from disorder in an open system. We do know much more than in 1983 when Asimov posed anew this question, but humility is important in understanding the limits of our knowledge as we quest for a solution to this grand cosmological question.

And what does the story of life's beginnings on Earth reveal about the possibility of life elsewhere in the Universe? Answers to those questions are among the most intriguing and profound that science can ask. I commend the reading of this monograph and the one to follow for all those who join in searching for an understanding of how nonlife can be transformed into life, somewhere, somehow.