

ARTIFICIAL CHEMISTRIES

WOLFGANG BANZHAF AND LIDIA YAMAMOTO

The field of Artificial Life (ALife) is now firmly established in the scientific world, but it has yet to achieve one of its original goals: an understanding of the emergence of life on Earth. The new field of artificial chemistries draws from chemistry, biology, computer science, mathematics, and other disciplines to work toward that goal. For if, as it has been argued, life emerged from primitive, prebiotic forms of self-organization, then studying models of chemical reaction systems could bring ALife closer to understanding the origins of life.

In artificial chemistries (ACs), the emphasis is on creating new interactions rather than new materials. The results can be found both in the virtual world, in certain multiagent systems, and in the physical world, in new (artificial) reaction systems. This book offers an introduction to the fundamental concepts of ACs, covering both theory and practical applications.

After a general overview of the field and its methodology, the book reviews important aspects of biology, including basic mechanisms of evolution; discusses examples of ACs drawn from the literature; considers fundamental questions of how order can emerge, emphasizing the concept of chemical organization (a closed and self-maintaining set of chemicals); and surveys a range of applications, which include computing, systems modeling in biology, and synthetic life. An appendix provides a Python toolkit for implementing ACs.

Wolfgang Banzhaf is University Research Professor and Head of the Department of Computer Science at the Memorial University of Newfoundland. Lidia Yamamoto is a former Postdoctoral Researcher at the University of Basel.

"A feast of theoretical and practical information about contemporary computational models of fundamental chemical phenomena, including chemical reaction networks, autocatalytic networks, organizations and self-organization, autopoiesis, the origin of life, and even the emergence and open-ended evolution of chemical novelty and complexity. This is the go-to-first source for any question about artificial chemistry."

—Mark A. Bedau, Professor of Philosophy and Humanities, Reed College; Adjunct Professor of Systems Science, Portland State University; and Editor-in-Chief of *Artificial Life*

"I found this to be a fascinating and essential read for anyone interested in artificial life research. The book is very well-organized and provides both the specialist and non-specialist alike with lots of well-referenced examples and also integrates over many of the most important fields from concepts of living systems to evolution, artificial chemistries, computational aspects, and the need for entire system exploration."

—Leroy (Lee) Cronin, Regius Professor of Chemistry, School of Chemistry, University of Glasgow

"This book by Banzhaf and Yamamoto provides an excellently written introduction and survey on the state of the art in the young new discipline of artificial chemistries and has the potential to become the key publication in the field."

—Peter Schuster, Professor Emeritus, Institute for Theoretical Chemistry, University of Vienna

Cover image: Molecular model of a ribosome (iStockphoto LP © Martin McCarthy). Found in every living cell, ribosomes operate like true molecular machines, reading information from messenger RNAs and faithfully translating it into proteins. They have been compared to Turing machines, with RNA and proteins being regarded as Turing "tapes" that store information. The notion of biochemical Turing machines has inspired many artificial chemistries to date, some of them implemented *in silico*, others built in actual wet chemistry.

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