
Klaus Mainzer Thinking in Complexity

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Thinking in Complexity

The Complex Dynamics
of Matter,
Mind, and Mankind

Third Revised and Enlarged Edition
With 126 Figures



Springer

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*Das Ganze aber ist nur das durch seine Entwicklung
sich vollendende Wesen. **

G. W. F. Hegel: Phänomenologie des Geistes (1807)

** The whole, however, is merely the essential nature reaching its
completeness through the process of its own development.*

G. W. F. Hegel: The Phenomenology of Mind (1807)

Preface to the Third Edition

The second edition of “Thinking in Complexity”, like the first edition, was also sold out in less than one year. Meanwhile, Japanese and Chinese translations of the second edition have been published. Once more I have taken the opportunity provided by a new edition to revise and extend the text.

A new Sect. 2.5 “Complex Systems and the Self-Construction of Materials” is included, in order to analyze the role of complex systems in the dramatic success of supramolecular chemistry, nanotechnology, and the technology of smart (“intelligent”) materials. These topics lie at the boundary between materials science and life science. In recent years, life science and computer science have been growing together in a common field of research called “artificial life”. A further new Sect. 5.5 “From Artificial Intelligence to Artificial Life” has been added, in which the role of complex systems in the field of artificial life is discussed. I also use the opportunity of the new edition to make some remarks about the relationship between the Santa Fe approach to complex systems and the methods of synergetics and order parameters which are key concepts in this book.

Research into complex systems continues worldwide. I have to thank the readers who have written friendly and inspiring letters from all over the world. Some months ago, a German Society of Complex Systems and Nonlinear Dynamics was founded. The honorable German Academy of Natural Scientists Leopoldina invited me to give a lecture on complexity for which I express my gratitude. Last but not least, I would again like

to thank Wolf Beiglböck of Springer-Verlag for initiating and supporting this new edition.

Augsburg, November 1996

Klaus Mainzer

Preface to the Second Edition

The first edition of “Thinking in Complexity” was sold out in less than one year. Obviously, complexity and nonlinearity are “hot” topics of interdisciplinary interest in the natural and social sciences. The situation is well summarized by a quotation of Ian Stewart (Mathematics Institute, University of Warwick) who wrote a nice review of my book under the title “Emerging new science” [*Nature* **374**, 834 (1995)]: “Nonlinearity is not a universal answer, but it is often a better way of thinking about the problem”.

I have taken the opportunity provided by a second edition to revise and extend the text. In Sect. 2.4 a supplement is included on the recent importance of conservative self-organization in supramolecular chemistry and the material sciences. Some references are given to the recent discussion of self-organization in alternative cosmologies. Some remarks are made about new results on dissipative self-organization in living cells (Sect. 3.3). The success and limitations of adaptive neural prostheses in neurotechnology are analyzed in more detail (Sect. 5.4). The last chapter is extended into an “Epilogue on Future, Science, and Ethics”: After a short introduction to traditional forecasting methods, their limitations and new procedures are discussed under the constraints of nonlinearity and complexity in the natural and social sciences. In particular, the possibilities of predicting and modeling scientific and technological growth are extremely interesting for the contemporary debates on human future and ethics.

General methods of nonlinear complex systems must be developed in cooperation with the natural and social

sciences under their particular observational, experimental, and theoretical conditions. Thus, I want to thank some colleagues for their helpful advice: Rolf Eckmiller (Dept. of Neuroinformatics, University of Bonn), Hans-Jörg Fahr and Wolf Priester (Dept. of Astrophysics and Max-Planck Institute for Radioastronomy, Bonn), Hermann Haken (Institute of Theoretical Physics and Synergetics, Stuttgart), Benno Hess (Max-Planck Institute for Medical Research, Heidelberg), S. P. Kurdyumov (Keldysh Institute of Applied Mathematics, Moscow), Renate Mayntz (Max-Planck Institute for Social Sciences, Cologne), Achim Müller (Dept. of Inorganic Chemistry, University of Bielefeld). Last but not least, I would like to thank Wolf Beiglböck (Springer-Verlag) for initiating and supporting this new edition.

Augsburg, November 1995

Klaus Mainzer

Preface to the First Edition

Complexity and nonlinearity are prominent features in the evolution of matter, life, and human society. Even our mind seems to be governed by the nonlinear dynamics of the complex networks in our brain. This book considers complex systems in the physical and biological sciences, cognitive and computer sciences, social and economic sciences, and philosophy and history of science. An interdisciplinary methodology is introduced to explain the emergence of order in nature and mind and in the economy and society by common principles.

These methods are sometimes said to foreshadow the new sciences of complexity characterizing the scientific development of the 21st century. The book critically analyzes the successes and limits of this approach, its systematic foundations, and its historical and philosophical background. An epilogue discusses new standards of ethical behavior which are demanded by the complex problems of nature and mind, economy and society.

The “nucleus” of this book was a paper contributed to a conference on complex nonlinear systems which was organized by Hermann Haken and Alexander Mikhailov at the Center for Interdisciplinary Studies in Bielefeld, in October 1992. In December 1992, Dr. Angela M. Lahee (Springer-Verlag) suggested that I elaborate the topics of my paper into a book. Thus, I would like to express my gratitude to Dr. Lahee for her kind and efficient support and to Hermann Haken for his cooperation in several projects on complex systems and synergetics. I also wish to thank the German Research Foundation (DFG) for the support of my projects on “Computer, Chaos and Self-organization” (1990–1992: Ma 842/4-1)

and “Neuroinformatics” (1993–1994: Ma 842/6-1). I have received much inspiration from teaching in a mathematical graduate program on “Complex Systems” (supported by the DFG) and an economic program on “Nonlinearity in Economics and Management” at the University of Augsburg. In 1991 and 1993, the Scientific Center of Northrhine-Westphalia (Düsseldorf) invited me to two international conferences on the cultural effects of computer technology, neurobiology, and neurophilosophy.

Last but not least, I would especially like to thank J. Andrew Ross (Springer-Verlag) for carefully reading and correcting the book as a native speaker, and Katja E. Hüther and Jutta Janßen (University of Augsburg) for typing the text.

Augsburg, June 1994

Klaus Mainzer

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