Preface

This book is, of course about complexity. The title of the book, as you may recognize was motivated (excuse me for using this very mild expression) by Daniel Dennett's Consciousness Explained [130]. Dennett's intention was to explain consciousness as the emergent product of the interaction among constituents having physical and neural character. The goal of this book is to explain how various types of complexity emerge due to the interaction among constituents. There are many questions to be answered, how to understand, control, decompose, manage, predict the many-faced complexity. After teaching this subject for several years I feel that the time has come to put the whole story together.

The term "complex system" is a buzzword, but we certainly don't have a single definition for it. There are several predominant features of complexity. Complex processes may show unpredictable behavior (which we still try to predict somehow), may lead to uncontrolled explosion (such in case of epilepsy, earthquake eruptions or stock market crashes). One of the characteristic feature of simple systems is, that there is a single cause which implies a single effect. For large class of complex systems it is true that effects are fed back to modify causes. Biological cells belong to this class. Furthermore they are open to material, energetic and information flow by interaction with their environment, still they are organizationally closed units. Another aspect of complexity is the question how collective phenomena emerge by some self-organized mechanisms. Thomas Schelling's model, which suggests that strong racial prejudice is not needed to generate urban segregation, is paradigmatic.

There is a remarkable and unique statistical feature of certain complex systems. Generally we expect that there is an average, (say, the average height of people), and the deviation from this average is symmetric. Biologists have found that the Gaussian distribution can be applied in many, many cases. In a large number of social systems (but not only there) we see another type of pattern, occasionally called as the 80/20 rule. About 80 percent of the income is made by 20% of people, 80% (well, 70 or 85) of flights are landing on twenty percent of the airports, while there are many small airports with

a few flights per day. A large number of scientific papers are written by a small number of scientists, and so on. Such kinds of phenomena, which don't really have a characteristic size, are described by an asymmetric (skew) so-called power law distribution. The brilliant best-seller of Douglas Hofstadter on Gödel, Escher and Bach published in 1979 emphasized self-reference and loops, actually he calls a strange loop. Loops, specifically feedback loops were studied by cybernetics, an abandoned scientific discipline, which emphasized that effects may feed back to influence causes. Such kinds of systems, which are characterized by "circular causality" certainly could be qualified to be called as complex.

I would like to mention three books, which influenced the way of my writing. Heinz R. Pagels' (1939–1988) posthumous book "The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity" [395], a very exciting book about chaos, complexity, neural networks, cognitive science, and philosophy of science. I think I remember the excitement I felt when I read at least half of the book in the same breath in a trans-Atlantic flight, actually the first time from Michigan to Europe, in the incredible fall of Eastern Europe in 1989.

John Casti's "Paradigms lost" [94] showed me that it is possible to mention different fields in the same book from philosophy of science via molecular biology and origin of life, theory of evolution, sociobiology, linguistics, cognitive science, foundation of mathematics, to quantum physics and cosmology. I have a somewhat overlapping list.

I learned from Michael Arbib's "The Metaphorical Brain" [18] how to use and not use mathematical formalism. Some pages of his book are filled with equations, and then you may find fifty pages without any formulas. So, I extracted the implicit message to be "Don't be afraid to use math when it helps to explain your ideas, and don't be afraid to avoid mathematics when you can convey your ideas without it."

I have heard about the notions of complex systems, simulation methods, and thinking in models in the late sixties from my undergraduate mentor, Pál Benedek, and later had numerous conversation about the complexity of the brain with János Szentágothai.

It happened that this has been my sixth year to teach complex systems and related fields at Kalamazoo College for undergraduates. Kalamazoo College was awarded by a Henry R. Luce Professorship, and I have had the privilege to serve here to build a program about complex systems. I learned (hopefully) a lot during these years, and the book grew up from my class notes. I benefited very much from the interaction with my colleague Jan Tobochnik. We have a mutual interest in understanding and making others understand problems, many of them are related to complex systems.

Previously I taught a History of Complex Systems Research class at the Department of History and Philosophy of Science at Eötvös University, Budapest (Hungary), when I served there as a Széchenyi professor, and the plan of writing a book about complexity emerged in that period.

I am particularly indebted to two of my Hungarian graduate students, Gábor Csárdi, Balázs Ujfalussy, who helped a lot in preparing the text and figures. Zsófi Huhn, Tamás Nepusz helped to complete specific sections.

I deliberately adopted/adapted texts, figures, ideas from works published earlier with a large set of coworkers, such as Ildikó Aradi, Michael Arbib, George Barna, Fülöp Bazsó, Tamás F. Farkas, Csaba Földy, Mihaly Hajos, Tamás Kiss, Máté Lengyel, Gergő Orbán, Zoltán Somogyvári, Katherine Strandburg, Krisztina Szalisznyó, János Tóth, Ichiro Tsuda and László Zalányi.

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I got a lot of motivations from the ELMOHA circle.

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While the book is dedicated to the memory of my parents, I think they would have suggested me to do it to my children. Zsuzsi and Gábor, the book is dedicated also to you.

We have a long experience with my wife, Csuti, to cope with the complexity of life. I benefited very much from her support, love and wisdom. I am not sure I could have completed this book without her deep understanding. It is difficult to express my gratitude.

Kalamazoo, Michigan and Budapest-Csillebérc   *Péter Érdi*
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