

THE SYSTEMS VIEW OF LIFE

A Unifying Vision

Over the past 30 years, a new systemic conception of life has emerged at the forefront of science. New emphasis has been given to complexity, networks, and patterns of organization, leading to a novel kind of “systemic” thinking.

This volume integrates the ideas, models, and theories underlying the systems view of life into a single coherent framework. Taking a broad sweep through history and across scientific disciplines, the authors examine the appearance of key concepts such as autopoiesis, dissipative structures, social networks, and a systemic understanding of evolution. The implications of the systems view of life for healthcare, management, and our global ecological and economic crises are also discussed.

Written primarily for undergraduates, it is also essential reading for graduate students and researchers interested in understanding the new systemic conception of life and its implications for a broad range of professions – from economics and politics to medicine, psychology, and law.

FRITJOF CAPRA is a Founding Director of the Center for Ecoliteracy in Berkeley, California, and serves on the faculty of Schumacher College (UK). He is a physicist and systems theorist, and has been engaged in a systematic examination of the philosophical and social implications of contemporary science for the past 35 years. He is also the best-selling author of *The Tao of Physics* (1975) and *The Web of Life* (1996).

PIER LUIGI LUISI is Professor of Biochemistry at the University of Rome 3. He started his career at the Swiss Federal Institute of Technology in Zurich, Switzerland (ETHZ), where he became full Professor of chemistry and initiated the interdisciplinary Cortona Weeks. His main research focuses on the experimental, theoretical, and philosophical aspects of the origin of life and the self-organization of synthetic and natural systems. He is also the author of *The Emergence of Life* (2006) and *Mind and Life* (2008).

THE SYSTEMS VIEW OF LIFE

A Unifying Vision

FRITJOF CAPRA

*Formerly of the Lawrence Berkeley National Laboratory,
California, USA*

PIER LUIGI LUISI

University of Rome 3, Italy



CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
 UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Published in the United States of America by Cambridge University Press, New York

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107011366

© Fritjof Capra and Pier Luigi Luisi 2014

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2014

Printed in the United Kingdom by TJ International Ltd, Padstow Cornwall

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Capra, Fritjof.

The systems view of life : a unifying vision / Fritjof Capra, formerly of the Lawrence Berkeley National Laboratory, CA, USA, Pier Luigi Luisi, University of Rome 3, Italy.

pages cm

Includes bibliographical references and index.

ISBN 978-1-107-01136-6 (hardback)

1. Science – Philosophy. 2. Science – Social aspects. I. Luisi, P. L. II. Title.

Q175.C2455 2014

304.201 – dc23 2013034908

ISBN 978-1-107-01136-6 Hardback

Additional resources for this publication at www.cambridge.org/9781107011366

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

At Cambridge University Press we are committed to using environmentally sustainable papers for all our publications. We ensure that all of our printers use papers accredited by the FSC or PEFC, or another local equivalent depending on the global location of the printer.

Cambridge University Press
978-1-107-01136-6 — The Systems View of Life
Fritjof Capra , Pier Luigi Luisi
Frontmatter
[More Information](#)

To the memory of
Francisco Varela (1946–2001),
who introduced us to each other and who inspired both of us
with his systemic vision and spiritual orientation

Contents

<i>Preface</i>	<i>page xi</i>
<i>Acknowledgments</i>	xiii
Introduction: paradigms in science and society	1
I THE MECHANISTIC WORLDVIEW	
1 The Newtonian world-machine	19
1.1 The Scientific Revolution	20
1.2 Newtonian physics	28
1.3 Concluding remarks	33
2 The mechanistic view of life	35
2.1 Early mechanical models of living organisms	35
2.2 From cells to molecules	36
2.3 The century of the gene	39
2.4 Mechanistic medicine	42
2.5 Concluding remarks	43
3 Mechanistic social thought	45
3.1 Birth of the social sciences	45
3.2 Classical political economy	49
3.3 The critics of classical economics	51
3.4 Keynesian economics	54
3.5 The impasse of Cartesian economics	55
3.6 The machine metaphor in management	57
3.7 Concluding remarks	59
II THE RISE OF SYSTEMS THINKING	
4 From the parts to the whole	63
4.1 The emergence of systems thinking	63
4.2 The new physics	68
4.3 Concluding remarks	79
	vii

viii	<i>Contents</i>	
5	Classical systems theories	84
5.1	Tektology	84
5.2	General systems theory	85
5.3	Cybernetics	87
5.4	Concluding remarks	97
6	Complexity theory	98
6.1	The mathematics of classical science	99
6.2	Facing nonlinearity	104
6.3	Principles of nonlinear dynamics	109
6.4	Fractal geometry	116
6.5	Concluding remarks	125
III A NEW CONCEPTION OF LIFE		
7	What is life?	129
7.1	How to characterize the living	129
7.2	The systems view of life	130
7.3	The fundamentals of autopoiesis	134
7.4	The interaction with the environment	135
7.5	Social autopoiesis	136
7.6	Criteria of autopoiesis, criteria of life	137
7.7	What is death?	139
7.8	Autopoiesis and cognition	141
7.9	Concluding remarks	143
8	Order and complexity in the living world	144
8.1	Self-organization	144
8.2	Emergence and emergent properties	154
8.3	Self-organization and emergence in dynamic systems	158
	Guest essay: Daisyworld	166
8.4	Mathematical patterns in the living world	168
8.5	Concluding remarks	180
9	Darwin and biological evolution	182
9.1	Darwin's vision of species interlinked by a network of parenthood	182
9.2	Darwin, Mendel, Lamarck, and Wallace: a multifaceted interconnection	185
9.3	The modern evolutionary synthesis	187
9.4	Applied genetics	193
9.5	The Human Genome Project	194
9.6	Conceptual revolution in genetics	195
	Guest essay: The rise and rise of epigenetics	198
9.7	Darwinism and creationism	207
9.8	Chance, contingency, and evolution	210

Contents

ix

9.9	Darwinism today	212
9.10	Concluding remarks	214
10	The quest for the origin of life on Earth	216
10.1	Oparin's molecular evolution	216
10.2	Contingency versus determinism in the origin of life	216
10.3	Prebiotic chemistry	220
10.4	Laboratory approaches to minimal life	227
10.5	The synthetic-biology approach to the origin of life	229
10.6	Concluding remarks	239
11	The human adventure	240
11.1	The ages of life	240
11.2	The age of humans	241
11.3	The determinants of being human	245
11.4	Concluding remarks	251
12	Mind and consciousness	252
12.1	Mind is a process!	252
12.2	The Santiago theory of cognition	255
12.3	Cognition and consciousness	257
	Guest essay: On the primary nature of consciousness	266
12.4	Cognitive linguistics	271
12.5	Concluding remarks	273
13	Science and spirituality	275
13.1	Science and spirituality: a dialectic relationship	275
13.2	Spirituality and religion	276
13.3	Science versus religion: a "dialogue of the deaf"?	282
13.4	Parallels between science and mysticism	285
13.5	Spiritual practice today	289
13.6	Spirituality, ecology, and education	290
13.7	Concluding remarks	295
14	Life, mind, and society	297
14.1	The evolutionary link between consciousness and social phenomena	297
14.2	Sociology and the social sciences	297
14.3	Extending the systems approach	301
14.4	Networks of communications	308
14.5	Life and leadership in organizations	315
14.6	Concluding remarks	320
15	The systems view of health	322
15.1	Crisis in healthcare	323
15.2	What is health?	326

x	<i>Contents</i>	
	Guest essay: Placebo and nocebo responses	329
	15.3 A systemic approach to healthcare	333
	Guest essay: Integrative practice in healthcare and healing	334
	15.4 Concluding remarks	338
IV	SUSTAINING THE WEB OF LIFE	
16	The ecological dimension of life	341
	16.1 The science of ecology	341
	16.2 Systems ecology	345
	16.3 Ecological sustainability	351
	16.4 Concluding remarks	361
17	Connecting the dots: systems thinking and the state of the world	362
	17.1 Interconnectedness of world problems	362
	17.2 The illusion of perpetual growth	366
	17.3 The networks of global capitalism	375
	17.4 The global civil society	389
	17.5 Concluding remarks	392
18	Systemic solutions	394
	18.1 Changing the game	394
	Guest essay: Living enterprise as the foundation of a generative economy	402
	18.2 Energy and climate change	405
	18.3 Agroecology – the best chance to feed the world	431
	Guest essay: Seeds of life	438
	18.4 Designing for life	442
	18.5 Concluding remarks	451
	<i>Bibliography</i>	453
	<i>Index</i>	472

Preface

As the twenty-first century unfolds, it is becoming more and more evident that the major problems of our time – energy, the environment, climate change, food security, financial security – cannot be understood in isolation. They are systemic problems, which means that they are all interconnected and interdependent. Ultimately, these problems must be seen as just different facets of one single crisis, which is largely a crisis of perception. It derives from the fact that most people in our modern society, and especially our large social institutions, subscribe to the concepts of an outdated worldview, a perception of reality inadequate for dealing with our overpopulated, globally interconnected world.

There *are* solutions to the major problems of our time; some of them even simple. But they require a radical shift in our perceptions, our thinking, our values. And, indeed, we are now at the beginning of such a fundamental change of worldview in science and society, a change of paradigms as radical as the Copernican revolution. Unfortunately, this realization has not yet dawned on most of our political leaders, who are unable to “connect the dots,” to use a popular phrase. They fail to see how the major problems of our time are all interrelated. Moreover, they refuse to recognize how their so-called solutions affect future generations. From the systemic point of view, the only viable solutions are those that are sustainable. As we discuss in this book, a sustainable society must be designed in such a way that its ways of life, businesses, economy, physical structures, and technologies do not interfere with nature’s inherent ability to sustain life.

Over the past thirty years it has become clear that a full understanding of these issues requires nothing less than a radically new conception of life. And indeed, such a new understanding of life is now emerging. At the forefront of contemporary science, we no longer see the universe as a machine composed of elementary building blocks. We have discovered that the material world, ultimately, is a network of inseparable patterns of relationships; that the planet as a whole is a living, self-regulating system. The view of the human body as a machine and of the mind as a separate entity is being replaced by one that sees not only the brain, but also the immune system, the bodily tissues, and even each cell as a living, cognitive system. Evolution is no longer seen as a competitive struggle for existence, but rather as a cooperative dance in which creativity and the constant emergence of novelty are the driving forces. And with the new emphasis on complexity, networks, and patterns of organization, a new science of qualities is slowly emerging.

This new conception of life involves a new kind of thinking – thinking in terms of relationships, patterns, and context. In science, this way of thinking is known as “systemic thinking,” or “systems thinking”; hence, the understanding of life that is informed by it is often identified by the phrase we have chosen for the title of this book: the systems view of life.

The new scientific understanding of life encompasses many concepts and ideas that are being developed by outstanding researchers and their teams around the world. With the present book, we want to offer an interdisciplinary text that integrates these ideas, models, and theories into a single coherent framework. We present a unified systemic vision that includes and integrates life’s biological, cognitive, social, and ecological dimensions; and we also discuss the philosophical, spiritual, and political implications of our unified view of life.

We believe that such an integrated view is urgently needed today to deal with our global ecological crisis and protect the continuation and flourishing of life on Earth. It will therefore be critical for present and future generations of young researchers and graduate students to understand the new systemic conception of life and its implications for a broad range of professions – from economics, management, and politics to medicine, psychology, and law. In addition, our book will be useful for undergraduate students in the life sciences and the humanities.

In the following chapters, we take a broad sweep through the history of ideas and across scientific disciplines. Beginning with the Renaissance and the Scientific Revolution, our historical account includes the evolution of Cartesian mechanism from the seventeenth to the twentieth centuries, the rise of systems thinking, the development of complexity theory, recent discoveries at the forefront of biology, the emergence of the new conception of life at the turn of this century, and its economic, ecological, political, and spiritual implications.

The reader will notice that our text includes not only numerous references to the literature, but also an abundance of cross-references to chapters and sections in this book. There is a good reason for this abundance of references. A central characteristic of the systems view of life is its nonlinearity: all living systems are complex – i.e., highly nonlinear – networks; and there are countless interconnections between the biological, cognitive, social, and ecological dimensions of life. Thus, a conceptual framework integrating these multiple dimensions is bound to reflect life’s inherent nonlinearity. In our struggle to communicate such a complex network of concepts and ideas within the linear constraints of written language, we felt that it would help to interconnect the text by a network of cross-references. Our hope is that the reader will find that, like the web of life, this book itself is also a whole that is more than the sum of its parts.

FRITJOF CAPRA, *Berkeley*
PIER LUIGI LUISI, *Rome*

Acknowledgments

The synthesis of concepts and ideas we present in this book took three decades to mature. During this time, we were fortunate to be able to discuss most of the underlying scientific models and theories with their authors and with other scientists working in those fields, as well as with each other. Many of our insights and ideas originated and were further refined in those intellectual encounters.

We are especially grateful

- to Humberto Maturana for many stimulating conversations about autopoiesis, cognition, and consciousness;
- to the late Francisco Varela for illuminating discussions and inspiring collaborations over two decades on a wide variety of topics in cognitive science;
- to the late Lynn Margulis for inspiring dialogues about microbiology, symbiogenesis, and Gaia theory;
- to Helmut Milz for many clarifying discussions of medicine and the systems view of health; and
- to Brother David Steindl-Rast for enlightening conversations over three decades about spirituality, art, religion, and ethics.

Fritjof Capra also would like to express his gratitude

- to the late Ilya Prigogine for inspiring conversations about his theory of dissipative structures;
- to the late Brian Goodwin for challenging discussions over many years about complexity theory, cellular biology, and evolution;
- to Manuel Castells for a series of stimulating, systematic discussions of fundamental concepts in social theory, of technology and culture, and of the complexities of globalization; and for his critical reading of parts of our manuscript;
- to Margaret Wheatley for inspiring dialogues over several years about complexity and self-organization in living systems and human organizations;
- to Hazel Henderson and Jerry Mander, for challenging discussions since the 1970s about sustainability, technology, and the global economy;

- to Miguel Altieri for enlightening tutorials about the theory and practice of agroecology and organic farming; and to Vandana Shiva for numerous inspiring conversations about science, philosophy, ecology, community, and the Southern perspective on globalization;
- to Terry Irwin, Amory Lovins, and Gunter Pauli for many informative conversations about ecodesign;
- to the late Ernest Callenbach for reading portions of the manuscript and offering many critical comments.

Pier Luigi Luisi would like to convey his thanks, in particular,

- to Michel Bitbol (MD, then PhD in quantum physics, and now professor of philosophy at CREA (Centre de Recherche en Épistémologie Appliquée), Paris, where he has worked with Francisco Varela), Matthieu Ricard (Tibetan monk, one of the main figures in the entourage of the Dalai Lama, who started as a PhD student in molecular biology and is still a lover of science), and Franco Bertossa (director of the ASIA center in Bologna) for stimulating discussions about life and consciousness;
- to Paul Davies, Stuart Kauffman, Denis Noble, and Paolo Saraceno for wide-ranging discussions on the subjects of their books; and, last but not least,
- to his students and younger coworkers for their continuous questioning, which obliged him to study more and come up with unexpected answers; special thanks are due, among many, to Matteo Allegretti, Luisa Damiano, Rachel Faiella, Francesca Ferri, Michele Lucantoni, and Pasquale Stano.

Both of us are greatly indebted to Angelo Merante for producing numerous technical drawings, and to Julia Ponsonby for three beautiful line drawings in Chapters 5, 8, and 16. Last but not least, we are grateful to our editor Katrina Halliday at Cambridge University Press for her enthusiastic support during the writing of this book, and to Ilaria Tassistro for seeing the manuscript through the publishing process.