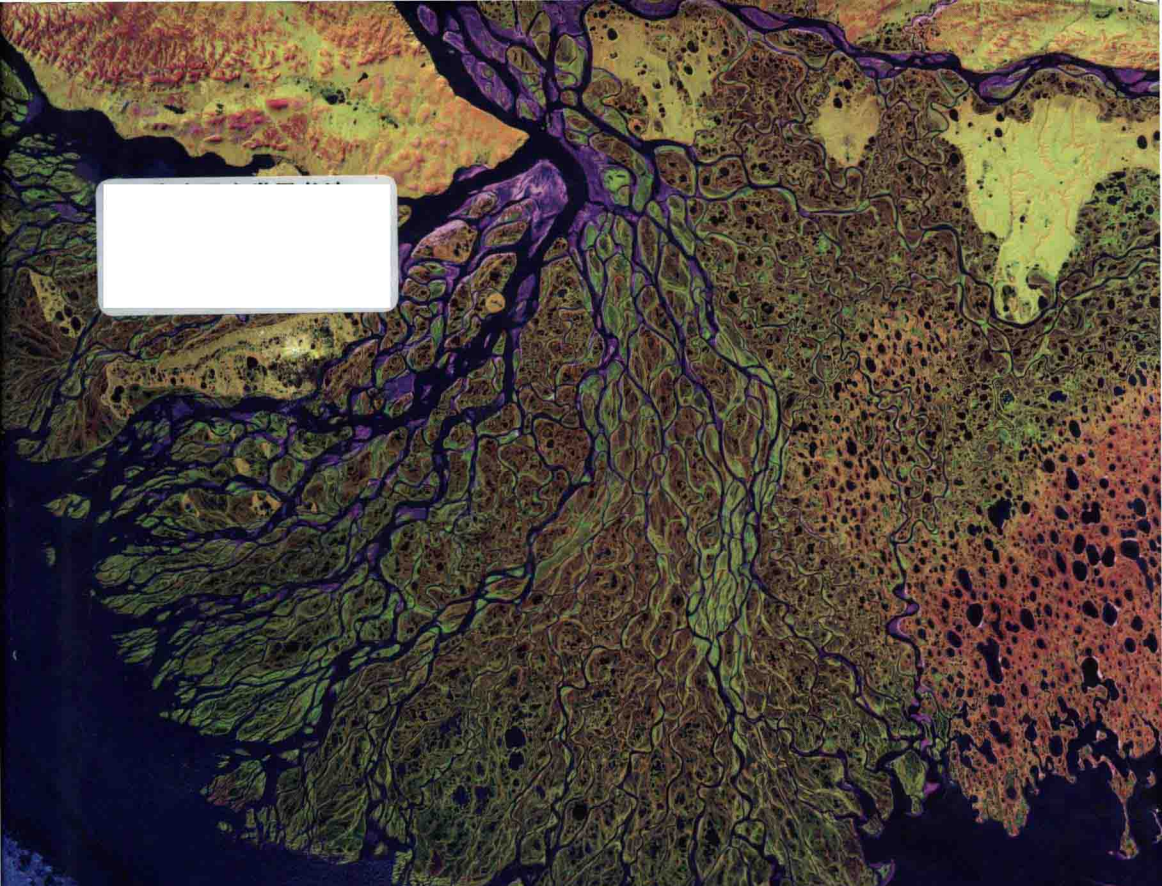

COMPLEXITY AND THE ARROW OF TIME

Edited by

Charles H. Lineweaver,
Paul C. W. Davies and
Michael Ruse

There is a widespread assumption that the universe in general, and life in particular, is "getting more complex with time." This book brings together a wide range of experts in science, philosophy, and theology and unveils their joint effort in exploring this idea.

They confront essential problems behind the theory of complexity and the role of life within it: What is complexity? When does it increase, and why? Is the universe evolving towards states of ever greater complexity and diversity? If so, what is the source of this universal enrichment? This book addresses those difficult questions, and offers a unique cross-disciplinary perspective on some of the most profound issues at the heart of science and philosophy. Readers will gain insights into complexity that reach deep into key areas of physics, biology, complexity science, philosophy, and religion.

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PAUL C. W. DAVIES is a Regents' Professor and the founding Director of BEYOND: Center for Fundamental Concepts in Science at Arizona State University (ASU). He is also Principal Investigator in the Center for the Convergence of Physical Science and Cancer Biology and co-director of ASU's Cosmology Initiative. His research has spanned the fields of cosmology, gravitation, quantum field theory, astrobiology, and cancer research, with particular emphasis on black holes, the origin of the universe, the origin of life, and the origin of cancer – topics on which he has authored or co-authored 30 books. He is a Member of the Order of Australia, and the recipient of the Templeton Prize, the Bicentenary Medal of Chile, the Robinson Cosmology Prize, the Faraday Prize of The Royal Society, and the Kelvin Medal of the UK Institute of Physics. The asteroid 1992 OG was officially named "(6870) Pauldavies" in his honor.

MARCELO GLEISER is Appleton Professor of Natural Philosophy and professor of physics and astronomy at Dartmouth College. His research interests include the physics of the early universe, the properties of solitons in classical and quantum field theories, and questions related to the origins of life and self-organizing complexity. He is a fellow of the American Physical Society and an elected member of the Brazilian Academy of Philosophy. He serves on the editorial board of *National Geographic* magazine. His two science series for Brazil's TV Globo were watched by more than 30 million viewers. He writes a

weekly science column for a Brazilian newspaper and is the co-founder of a science and culture blog hosted by National Public Radio.

STUART A. KAUFFMAN, a biologist who was trained as a medical doctor, is Finland Distinguished Professor at Tampere University of Technology. He holds joint appointments as a visiting distinguished research professor at the University of Vermont in the College of Medicine and the College of Mathematical and Engineering Sciences. He is a fellow of the Royal Society of Canada, was awarded an honorary degree by the Catholic University of Louvain, was a MacArthur Fellow from 1987 to 1992, and received the Gold Medal of the Academia Lincea Rome. The former co-editor-in-chief of the *Journal of Theoretical Biology*, he has served on the editorial boards of many other journals and has written four books. His founding patents about what is sometimes called "molecular diversity" helped spawn a field known as combinatorial chemistry. He is well known for work on self-organization in evolution, complexity theory, and collectively autocatalytic sets for the origin of life. Recent work with G. Longo and M. Montevil (see Chapter 8) suggests that no laws entail the evolution of the biosphere.

DAVID C. KRAKAUER is Professor of Genetics at the University of Wisconsin-Madison, Director of the Wisconsin Institute for Discovery, and an external professor at the Santa Fe Institute. His research focuses on the evolutionary history of information processing mechanisms in adaptive systems. The current emphasis of his work is on robust information transmission and signaling dynamics, particularly their role in constructing novel, higher level structures, such as social systems and language. He moved on to the Santa Fe Institute as a professor in 2002 and was made faculty chair in 2009. He is a member of the editorial boards of the *Journal of Theoretical Biology*, *Theory in Biosciences*, *Biology*

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CHARLES H. LINEWEAVER is an associate professor at the Australian National University's Planetary Science Institute (PSI), a joint venture of the ANU Research School of Astronomy and Astrophysics and Research School of Earth Science. His research involves analysis of the statistical distribution of exoplanets, the cosmic microwave background radiation, and cosmological prerequisites for the formation of terrestrial planets and life. He is a member of the editorial board of *Astrobiology Magazine*.

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MICHAEL RUSE is a philosopher of science who has found in evolution a kind of *Weltanschauung*, a world picture that gives meaning to life. He is one of the foremost contemporary Darwin scholars. Ruse currently teaches at Florida State University. He has honorary degrees from the University of Bergen in Norway and McMaster University, and is a fellow of both the Royal Society of Canada and the American Association for the Advancement of Science (AAAS). The founding editor of *Biology and Philosophy*,

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DAVID WOLPERT is currently in the Information Sciences Division of Los Alamos National Laboratory and an external professor at the Santa Fe Institute. Previously he was Ulam Scholar at the Center for Non-linear Studies in Los Alamos. Earlier in his career, he was at the NASA Ames Research Center and a consulting professor at Stanford University, where he formed the Collective Intelligence group. He has worked at IBM and at a data mining startup, and been an external faculty member at numerous institutions. His current research focuses on game theory, the application of machine learning to both optimization and Monte Carlo methods, complexity measures, modeling evolution of technology, information theory, and the foundations of physics and inference. He is the author of three books, three patents, and more than one hundred refereed papers, and has won numerous awards.

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