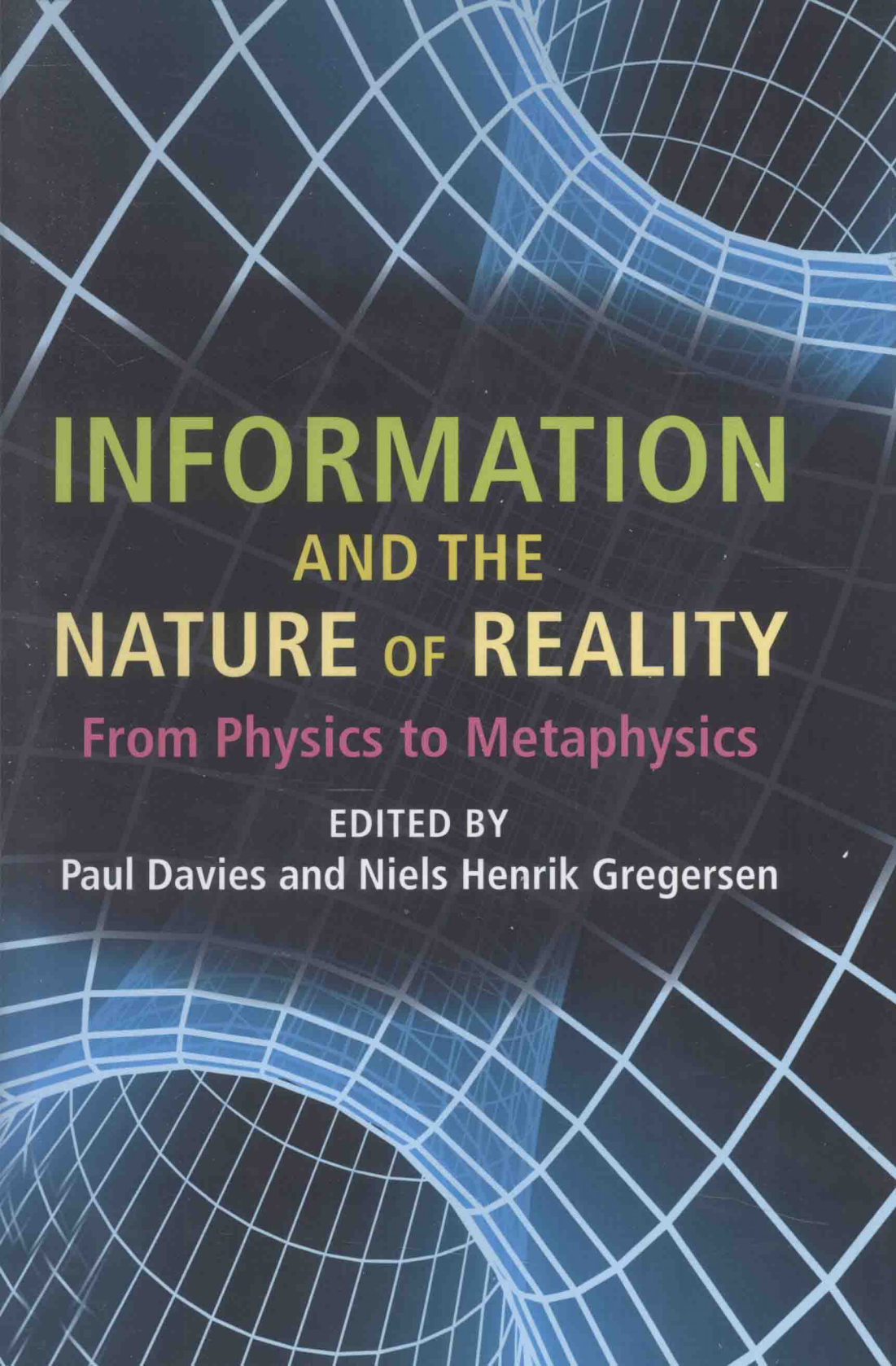
INFORMATION
AND THE
NATURE OF REALITY
From Physics to Metaphysics
EDITED BY
Paul Davies and Niels Henrik Gregersen

# Information and the Nature of Reality

## From Physics to Metaphysics

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## Information and the Nature of Reality
From Physics to Metaphysics

Many scientists regard mass and energy as the primary currency of nature. In recent years, however, the concept of information has gained importance.

In this book, eminent scientists, philosophers, and theologians chart various aspects of information, from quantum information to biological and digital information, in order to understand how nature works. Beginning with a historical treatment of the topic, the book also examines physical and biological approaches to information, and the philosophical, theological, and ethical implications.

*To the memory of Arthur R. Peacocke (1924–2006)*

# About the authors

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BERND-OLAF KÜPPERS studied physics and mathematics at the universities of Bonn and Göttingen. From 1971 to 1993 he worked at the Max Planck Institute for Biophysical Chemistry in Göttingen. Since 1994 he has been Professor of Natural Philosophy at the Friedrich Schiller University of Jena, and since 2008 also Director of the Frege Centre for Structural Sciences. Books include *Molecular Theory of Evolution* (1985), *Information and the Origin of Life* (1990), *Natur als Organismus* (1992), *Nur Wissen kann Wissen beherrschen* (2008) and *Wissen statt Moral* (2010). He is a member of Germany's National Academy of Sciences and of the Academia Europaea, London.

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ARTHUR R. PEACOCKE (1924–2006) was a biochemist and theologian from Oxford University. Having taught at Birmingham he returned to Oxford in 1959 as Professor of Physical Biochemistry. In this capacity he published more than 125 papers and three books. Later he resumed his theological interests, became ordained in 1971, and went to serve as Dean of Clare College, Cambridge University. In 1985 he became the founding director of the Ian Ramsey Centre, at Oxford. In 1992–1993 he gave the Gifford Lectures, published as *Theology for a Scientific Age* (1993). In a series of books, beginning with *Science and the Christian Experiment* (1971) and ending with *All That Is: A Naturalistic Faith for the Twenty-First Century* (2007), he laid the groundwork for a generation of younger scholars in the field of science and religion. In 2001 he was awarded the Templeton prize.

HOLMES ROLSTON, III is University Distinguished Professor and Professor of Philosophy Emeritus at Colorado State University. He has written eight books, including *Science and Religion: A Critical Survey* (most recent edition 2006), *Environmental Ethics* (1988), and *Three Big Bangs: Matter-Energy, Life, Mind* (2010). He gave the Gifford Lectures, University of Edinburgh, 1997–1998, published as *Genes, Genesis and God* (1999). He has lectured on all seven continents. He was named laureate for the Templeton Prize in Religion in 2003. A recent intellectual biography is *Saving Creation: Nature and Faith in the Life of Holmes Rolston III*, by Christopher J. Preston (2009).

JOHN MAYNARD SMITH (1920–2004) was a geneticist and theoretical evolutionary biologist. In the late 1950s and early 1960s he did pioneering work on the genetics of aging in fruit flies, and wrote *The Theory of Evolution* (1958). As the Founding Dean of the School of Biological Sciences at the University of Sussex (1965–1985), his interests turned into theoretical problems of evolutionary biology, especially concerning the relation between mathematics and life. He formalized the Evolutionary Stable Strategy (EES), today a standard tool in game theory. His classic works in theoretical biology include *The Evolution of Sex* (1978), *Evolution and the Theory of Games* (1982), and *The Major Transitions in Evolution* (with E. Szatmáry, 1997).

HENRY STAPP is a theoretical physicist at the University of California's Lawrence Berkeley Laboratory, specializing in the conceptual and mathematical foundations of quantum theory, and in particular on the quantum aspects of the relationship between our streams of conscious experience and the physical processes occurring in our brains. He is author of two books on this subject: *Mind, Matter, and Quantum Mechanics* (1993) and *Mindful Universe: Quantum Mechanics and the Participating Observer* (2007).

KEITH WARD is Emeritus Regius Professor of Divinity at Oxford University, Professorial research fellow at Heathrop College, London, and Fellow of the British Academy. Laid out in more than 25 books, his work covers wide areas, from systematic and philosophical theology to comparative theology and science and religion. In 2008 he finished a five-volume series of comparative theology, comparing the great religious traditions on concepts of revelation, creation, human nature, and community. Also in the field of science and religion he has produced a number of influential books, including more recently *Pascal's Fire: Scientific Faith and Religious Understanding* (2006) and *The Big Questions in Science and Religion* (2008).

MICHAEL WELKER held faculty positions at the universities in Tübingen and Münster before he was offered the Chair of Systematic Theology at Heidelberg in 1991. He has been Director of the University's Internationales Wissenschaftsforum and is currently the Director of the Research Center for International and Interdisciplinary Theology. His method is to work through Biblical traditions as well as through contemporary philosophical, sociological, and scientific theories to address questions of contemporary culture and religion. His influential works in theology include *Creation and Reality* (1999), *What Happens in Holy Communion?* (2000), and *God the Spirit* (2004). Contributions to science and religion include *The End of the World and the Ends of God* (2000) and *Faith in the Living God* (with John Polkinghorne, 2001).

# Acknowledgments

This book grew out of a symposium held in the Consistorial Hall of Copenhagen University on 17–19 August 2006 under the aegis of the John Templeton Foundation and the Copenhagen University Research Priority Area on Religion in the 21st Century. The aim of the conference was to explore fundamental concepts of matter and information in current physics, biology, philosophy and theology with respect to the question of ultimate reality.

We, the editors and co-chairs, arranged the symposium 'God, Matter and Information. What is Ultimate?' in close collaboration with Dr Mary Ann Meyers, the Director of the Humble Approach Initiative under the John Templeton Foundation. The Humble Approach supports cutting-edge interdisciplinary research, insofar as it remains sensitive to disciplinary nuances, while looking for theoretical linkages and connections. Such studies are especially needed in areas of research that are central to the sciences, pertinent for a contemporary metaphysics, and yet are difficult to conceptualize and present in overview.

We are grateful to Mary Ann Meyers for her ongoing enthusiasm and expertise, and to the John Templeton Foundation for sponsoring the symposium so generously. We also want to thank the Editorial Director of Cambridge University Press, Dr Simon Capelin, for his assistance and encouragement in the publication of this book, and the anonymous peer reviewers who supported it. Lindsay Barnes and Laura Clark of the Press have set the editorial standards for this volume and worked in close collaboration with graduate student Trine-Amalie Fog Christiansen at Copenhagen University, who worked as a research assistant on this book and time and again showed her analytical skills. We owe thanks to her, and to Mikkel Christoffersen for assisting in the last phase of the production and for preparing the index.

With two exceptions, all papers grew out of the Copenhagen symposium. We asked Professor Philip Clayton to write a brief philosophical history of the concept of matter, with special emphasis on modernity, and we thank him for doing this so swiftly and well. We also wanted to include the programmatic article of the late evolutionary biologist John Maynard Smith, 'The Concept of Information in Biology' (*Philosophy of Science* 67(2), June 2000); we acknowledge the journal for giving us the permission to reprint this article as Chapter 7 of this volume.

This volume is dedicated to the memory of Arthur Peacocke who, sadly, died on 21 October 2006. Arthur Peacocke was part of the group, but because of his illness he could not attend the conference, so his paper was discussed in his absence. Chapter 12 in this volume is one of the last works from his hand. Peacocke's research in biochemistry and in the intersection of theology and science is highly regarded, and his intellectual testimony can found in his posthumous *All That Is: A Naturalistic Faith for the 21st Century* (Fortress Press, 2007). But for many of us, Arthur was not just a great scholar, but a mentor, a fellow-inquirer, and a friend who continued to listen, explore, and ask for more. We are indeed indebted to Arthur for his personal combination of rigour and generosity.

# Contents

# 1 Introduction: does information matter?

**Paul Davies and Niels Henrik Gregersen**

It is no longer a secret that inherited notions of matter and the material world have not been able to sustain the revolutionary developments of twentieth-century physics and biology. For centuries Isaac Newton's idea of matter as consisting of 'solid, massy, hard, impenetrable, and movable particles' reigned in combination with a strong view of laws of nature that were supposed to prescribe exactly, on the basis of the present physical situation, what was going to happen in the future. This complex of scientific materialism and mechanism was easily amalgamated with common-sense assumptions of solid matter as the bedrock of all reality. In the world view of classical materialism (having its heyday between 1650 and 1900), it was claimed that all physical systems are nothing but collections of inert particles slavishly complying with deterministic laws. Complex systems such as living organisms, societies, and human persons, could, according to this reductionist world view, ultimately be explained in terms of material components and their chemical interactions.

However, the emergence of thermodynamics around 1850 already began to cast doubt on the universal scope of determinism. Without initially questioning the inherited concepts of corpuscular matter and mechanism, it turned out that the physics of fluids and gases in thermodynamically open systems can be tackled, from a practical point of view, only by using statistical methods; the aim of tracking individual molecules had to be abandoned. In what has been aptly been called *The Probabilistic Revolution* (Krüger, Daston, and Heidelberger, 1990), determinism became a matter of metaphysical

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belief rather than a scientifically substantiated position. By the 1870s a great physicist such as James Clerk Maxwell was already questioning the assumption of determinism by pointing to highly unstable systems in which infinitesimal variations in initial conditions lead to large and irreversible effects (later to become a central feature of chaos theory). It was not until the twentieth century, however, that the importance of non-equilibrium dissipative structures in thermodynamics led scientists such as Ilya Prigogine (1996) to formulate a more general attack on the assumptions of reversibility and scientific determinism.

What happened, then, to the notion of matter and the material? In a first phase the term 'matter' gradually lost its use in science to be replaced by more robust and measurable concepts of mass (inertial, gravitational, etc). The story of the transformations of the idea of matter into something highly elusive yet still fundamental is told in detail by Ernan McMullin and Philip Clayton in Chapters 2 and 3 of this volume. Here it suffices to point to three new developments of twentieth-century physics in particular that forced the downfall of the inherited Matter Myth, and led to new explorations of the seminal role of information in physical reality.

The first blow came from Einstein's theories of special relativity (1905) and general relativity (1915). By stating the principle of an equivalence of mass and energy, the field character of matter came into focus, and philosophers of science began to discuss to what extent relativity theory implied a 'de-materialization' of the concept of matter. However, as McMullin points out, even though particles and their interactions began to be seen as only partial manifestations of underlying fields of mass-and-energy, relativity theory still gave room for some notion of spatio-temporal entities through the concept of 'rest mass'.

The second blow to classical materialism and mechanism came with quantum theory, which describes a fundamental level of reality, and therefore should be accorded primary status when discussing the current scientific and philosophical nature of matter.