

Preface to Third Edition

It's been ten years since the Second Edition went to press. Thanks to World Scientific and the many readers who bought the book, it was reprinted five times, the last in 2006; that is enough encouragement for a new edition of what is *still* the only book of its kind.

All the more so, as there have been significant advances in major areas of scientific research which lend additional support to the central idea developed in this book, that the organism is quantum coherent. I am referring to the remarkable empirical and theoretical findings in quantum entanglement and weak measurements, the tantalising properties of water, especially water in tissues and cells, the fractal dynamics of biological rhythms, the electronic and electromagnetic basis of biological organisation, and the thermodynamics of sustainable systems as organisms.

The quantum coherent organism has profound implications for our everyday life, ranging from our understanding of cell biology and medicine, education, health, sustainable energy and environmental policies, to knowledge acquisition and the meaning of life itself. It is in many ways the paradigm change we need in science to overcome the current crisis in climate change as fossil fuels are fast depleting, and droughts and floods are taking their toll in lives, homes and agricultural production all over the world. That is why I feel this new edition is timely, and I have Lance Sucharov, commissioning editor of World Scientific, to thank for asking me to do it.

As in the previous edition, I have edited and updated the book extensively throughout while keeping to the main narrative. Additional chapters and sections are intercalated at the appropriate places.

There are five extra chapters since the Second Edition (eight more since the First). The substantial additions are as follows. Chapter 7 is completely new, and deals with the application of the zero-entropy model of the organism to sustainable systems, specifically a zero-waste food and energy 'Dream Farm 2', and a brief diversion on the energy and entropy equivalents of money. Chapter 8 of the Second Edition has expanded to become Chapters 9, 10 and 11, to give emphasis to the disparate themes of electromagnetic theory, coherent excitation, and the 'solid-state cell' respectively, with a new section on how molecules do intercommunicate by resonating to the same electromagnetic frequencies (Chapter 11). Chapter 9 of the previous edition is now Chapters 12 and 13; Chapter 12, almost entirely new, describes fascinating discoveries on the fractal coherent dynamics of the healthy heartbeat, and how biofeedback may help to get the heart rhythm into a coherent state to improve general health and well being. Chapter 13 contains additional material on the non-thermal effects of microwaves in mobile phone and wi-fi technologies. Chapter 12 of the Second Edition is now Chapter 16, with new sections on quantum coherence and consciousness. The present Chapter 17 is entirely new and deals with the recent findings on water, especially water constituting the liquid crystalline matrix of the organism, which plays the lead role in energy transduction, intercommunication and more. Chapter 13 of the previous edition is now much enlarged as Chapter 18, with new sections on the quantum coherent universe, quantum phases and weak measurement.

Chapters 3 and 6 contain extra illustrations to clarify the storage of coherent energy tied to the characteristic space-time of processes that create the most efficient and rapid energy mobilisation, and also make explicit the zero-entropy model of the coherent organism that minimises not only the accumulation of entropy within but also the entropy exported to the environment.

My job has been made much easier, as since the Second Edition was published, I have become director of the Institute of Science

in Society (ISIS), a not-for-profit organisation dedicated to providing critical public information on cutting edge science, and to promoting social accountability and ecological sustainability in science. This has given me a lot of opportunity to keep up with the scientific literature and hone my skills at communicating science to the public. Most of the new materials in this edition are taken from published articles in ISIS' quarterly magazine, *Science in Society* (see www.i-sis.org.uk). I take this opportunity to thank my colleagues at ISIS for their tireless and ingenious contributions to improving the articles and promoting our cause: Peter Saunders, Emeritus Professor of Applied Mathematics at King's College, London University and co-founder of ISIS (with whom I share my life, work, and dreams); Joe Cummins, Emeritus Professor of Plant Genetics at University of Western Ontario, Canada, long-time collaborator in everything to do with genetic engineering, associate editor and major contributor to *Science in Society*, who has also kept me up-to-date with the scientific literature; Peter Bunyard (science editor of *The Ecologist*), associate editor and contributor to *Science in Society*, much published author on climate change and nuclear energy issues; and ISIS researchers Julian Haffegge, Sam Burcher, and Andy Watton, who have created the marvellous Quantum Jazz DVD accompanying this edition. I am especially grateful to colleagues in Third World Network (TWN), partner organisation of ISIS and collaborators on implementing Dream Farm 2: Martin Khor (director of TWN, and chief instigator for the founding of ISIS), Chee Yoke Ling, Lim Li Ching, Lim Li Lin, Sue Edwards and Tewolde Berhan Gebre Egziabher (also Institute of Sustainable Development in Ethiopia responsible for promoting organic sustainable agriculture to the country), and Hira Jhamtani (also Konphalindo in Indonesia).

ISIS has been most fortunate to have the support of elected representatives across the political spectrum sympathetic to at least some of the ideas expressed in this book. Among: UK Members of Parliament, I would like to mention ex-Environment Minister, the Right Honourable Michael Meacher (a special friend), Alan Simpson, Peter Ainsworth and Tim Yeo. Among the Members of the European Parliament, Dr. Caroline Lucas, Jill Evans, and Janucz Wojciechowsky have all supported and promoted our cause admirably.

This is also the occasion to thank the friends and sponsors of ISIS over the years: Jean-Louis Gueydon, Eva Novotny, Josephine Sikabonyi, Emidio Carvalho, Yoshi Honda, Antonio and Javier Claparoles, Paul McCartin, and Vera Chaney; also the many scientists who have worked with us informally, among them Malcolm Hooper, Vyvyan Howard, Arpad Pusztai, Stanley Ewen, Elizabeth Bravo, Lilian Joensen, and Pietro Perrino.

Franco Musumeci has done more than anyone else to keep me involved in the physics of organisms since the 1990s. He has continued to invite me to collaborate in research in his laboratory in sunny Catania with his colleagues Agata Scordino and Antonio Triglia, and is responsible for the happiest, most stimulating hours of lab work I have done within the past decade; always interspersed with splendid excursions to the beach, historic sites, and great meals. Our joint work has given us new insights into phase transitions of tissue water.

Robert Ulanowicz, Emeritus professor of theoretical ecology at the University of Maryland in the United States contacted me out of the blue in 2004, and I managed to persuade him to co-author a paper with me, which took the thesis of sustainable systems as organisms much further than I would have done myself. On the same subject, I am also grateful to George Chan, whose Integrated Food and Waste Management System is an independent implementation of the zero-entropy model of the organism as sustainable system. It has inspired Dream Farm 2, and showed me how sustainable development is possible. Peter Saunders and I were fortunate to have been hosted most generously and graciously by Prof. Zhong Ying and Prof. Zhang Hongou, director of Guangzhou Institute of Geography, where we were privileged to meet the team of scientists led by Prof. Zhong Gongfu. The team had studied the dyke-pond system of the Pearl River Delta, and showed how the Chinese peasants have long ago anticipated the zero-entropy model of sustainable systems by operating the dyke-pond system as a 'circular economy'.

Gerald Pollack, professor of biophysics at University of Washington in Seattle, invited me to the Gordon Conference on Interfacial Water in Cell Biology in 2004, the most significant conference I have

attended within the past ten years. I met almost all the pioneering water researchers there: Gilbert Ling, Martin Chaplin, Ludwig Edlmann, Frank Mayer, and Norio Ise, whose work, along with that of Philippa Wiggins, are featured in this edition.

Vejko VejkoVIC, head of the Center for Multidisciplinary Research and Engineering, Institute of Nuclear Sciences in Belgrade, Serbia, has been collaborating with us in ISIS on a project involving HIV and AIDS. So imagine my delight when I discovered he has been involved in pioneering a new method for drug discovery based on electromagnetic intercommunication between molecules. His work with Irena Cosic is now featured in this edition, thanks to the papers they sent to me.

My thanks to Russell Hebert for introducing me to his recent work demonstrating extraordinary coherence in the brainwaves during transcendental meditation and much else besides.

A very big thank you to Mario Pianesi and Loredana of Un Punto Macrobiotico who invited Peter and myself to meet with them and their scientists in Calabria, where intense discussions on energy in living systems and traditional Chinese medicine amid their generous hospitality next to the clear blue sea and sky gave just that extra momentum I needed to finish this edition.

Special appreciation goes to Jim Oschman for putting contemporary science into energy medicine, which inspired me to put energy medicine into contemporary science. This is where holistic health is heading, leading us out of the public health crisis created by decades of reductionist, mechanistic medicine.

Last but certainly not the least, I would like to pay homage to Edward Goldsmith, Founding Editor of *The Ecologist* and celebrated author of *Blue Print for Survival*, not only for his generous support for ISIS, but especially as one who has inspired much of the new work in this edition, by his tireless campaign on behalf of our planet and his scholarship in the organic philosophy that informs all of my work.

London
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Preface to Second Edition

Why produce a new edition of this book?

First, it is still the only book of its kind. Second, it has made me many friends since it appeared in print in 1993, some of whom became my collaborators in research. Third, all the friends I have made taught me a great deal more about the subject, thus revealing the shortcomings of my book. Fourth, while the book has lost little of its original appeal, there has been significant progress in the subject matter, both in the general scientific literature, and in research done by myself and my collaborators since the book was published. For all those reasons, I believe a new edition is necessary to do justice to the book and its subject matter.

Indeed, the progress made since 1993 warrants at least three new chapters: 6, 11 and 12. Chapter 6 presents a 'thermodynamics of organised complexity' especially applicable to living systems, and contains work that I have done since 1993, which, in many ways, extends and completes the thermodynamic enquiry into the living system presented in the early chapters. Chapters 11 and 12 deal with the idea that organisms are liquid crystalline, again, extending work which began in 1993, to which my co-workers and collaborators have contributed an enormous amount. The liquid crystalline nature of organisms, may, to a large extent, account for their most paradoxical properties, including pattern formation and the faculties of consciousness.

The additional chapters have been intercalated into the previous edition, which has been preserved in its form and substance, with extensive updating throughout. I have been able to simplify and clarify

the narrative with the benefit of hindsight, at the same time fleshing out the original account with fresh evidence. All the chapters are inevitably longer, but that is more than justified by the wealth of additional material which is beginning to give clear definition to a theory of the organism. Let me list some of the highlights.

Chapter 3 contains new evidence for resonant energy transfer in living systems. Chapter 4 contains new information on the Bénard cells from Koschmeider's book on the subject published in 1993. Chapter 7 includes extra material on the structure of water. Chapter 8 includes a description of Donald Ingber's model of the cell as a tensgrity system. Chapter 9 has been substantially edited, with more evidence on the biological effects of electromagnetic fields. Chapter 10 contains a substantial update on research into biophotons and their relationship to energy mobilisation. Chapters 13–15 connect entropy generation with quantum decoherence and refer to recent experimental work demonstrating quantum superposition on the mesoscopic scale. There is a new section on the fractal structure of organic space-time. There are, of course, numerous extra references.

I hope the reader will find much to think about and will continue to point out to me the shortcomings of this volume.

It remains for me to thank the many friends who have helped shape this edition. David Knight introduced me to much of the literature on liquid crystals, collaborated with us in the experimental work, offering expert advice and brilliant ideas at all times. Eric Schneider told me about Koschmeider's work and a wealth of other literature on the thermodynamics of living systems, including his own excellent work on ecosystems. I benefited enormously by having been guest of him and his wife Carol in their beautiful home in Montana, where I learned a lot, not only about thermodynamics, but also ecology and energy metabolism of organisms. Philip Herbomel brought zebrafish to our laboratory and spent a week with us, studying its development. He acquainted me with many exciting developments in France, including Nottale's work on fractal space-time. Ervin Laszlo inspired me with his book, *The Interconnected Universe*, to the possibility that the liquid crystalline continuum of the body may be a quantum

holographic medium. He has also kindly arranged for my book to be translated into German, which is another reason for this new edition.

Douglas Kell and Rickey Welch connected me to the whole radical world of biothermokinetics, which shows that there is life after the chemi-osmotic theory. Franklin Harold wrote to tell me he swallowed neither worm nor rainbow whole, and challenged me to think more deeply on bioenergetics. James Clegg initiated me into the mysteries of *Artemia*, the brine shrimp whose portrait graces the cover of this book. Rufus Lumry taught me everything I have always wanted to know about the bioenergetics of enzyme action and the importance of water and hydrogen bonds.

Walter Freeman introduced me to his fascinating work on the collective, possibly nonlocal synchronisation of brain waves. Alex Andrews spurred me on to write a paper on the subject. Peter Marcer drew my attention to quantum holography, quantum computing and his fascinating model of quantum perception. Michael Conforti brought me into the world of Jungian archetypes and the collective unconscious.

I would like mention all my old friends who continue to share my enthusiasm for the physics of organisms, especially the following with whom I have discussed many ideas during their formative phases: Kenneth Denbigh whose work was the major inspiration for the thermodynamics of organised complexity, Lynn Trainor on liquid crystals and the morphogenetic field, Franco Musumeci and Fritz Popp on the coherence of biophotons, Charles Jencks whose book, the *Jumping Universe*, inspired me to think about architecture and space-time, and hence, the architecture of space-time; Nick Furbank on determinism and freewill; and Geoffrey Sewell, as always, who answers any random questions on physics that presents itself during our happy lunch hours at the Spaniard.

I am grateful to all who have supported and sustained us in our experimental research efforts: Steve Swithenby for his abiding interest and support, as well as his expert advice on electromagnetism; Lyndon Davies who coordinated the only major grant I have received in

support of research into the physics of organisms; Gordon Evans, Alex Todd and Derek Welsh of Prior Scientific, Mark Willamson Mark Norris and Ian Young of Data Cell, Lynn Yeates, Derek Batchelor, Barry Hollis, Alan Bassindale, Jim Iley and Mike Mortimer of the Open University, all of whom took some of the ideas expressed in this book seriously; and Ron Hussey, Martin Bellis, Fraser Robertson and others, of the Open University Workshops, who skilfully constructed crucial pieces of laboratory equipment. I am also deeply appreciative of Franco Musumeci's efforts to keep us involved in biophotons research in sunny Catania.

Finally, I would like to thank my co-workers during the past five years, without whom this edition would not have been possible. Julian Haffegge, Zhou Yu-ming, Stephen Ross, John Bolton and Richard Newton, who have done much of the work described in Chapters 10, 11 and 12.

Milton Keynes
July 1997

Preface to First Edition

This book began 30 years ago when as a young undergraduate, I came across Szent Györgyi's idea that life is interposed between two energy levels of the electron. I was so smitten with the poetry in that idea that I spent the next 30 years searching for it. Naturally, I went at once into biochemistry. But I arrived too late. For the heady days of unity in diversity, the wine-and-roses days of discoveries in the universal energy transformation processes in living organisms had long been eclipsed by the new excitement over the molecular basis of heredity: the structure of the DNA double-helix and the cracking of the genetic code whereby the linear structure of DNA specifies the linear structure of proteins. So I became a geneticist; but found to my dismay that no one cared about unity anymore. Instead, almost everyone was obsessed with diversity and specificity: each biological function has a specific protein encoded by a gene 'selected by hundreds of millions of years of evolutionary history' to do the job.

After some years getting acquainted with a group of enzymes involved in a number of hereditary neurological disorders, I became an evolutionist. Together with Peter Saunders, we set out to try to understand the relevance of thermodynamics to evolution, and other 'big' questions such as how life began. Sidney Fox's work on thermal proteins was the antithesis to the then dominant 'frozen accident' theory of prebiotic evolution, and impressed on me the non-randomness, or I should say, non-arbitrary nature of life's physicochemical beginnings. I spent the next years working towards an alternative research programme to the neo-Darwinian theory of evolution by

the natural selection of random mutations. This involved investigations on the relationship between development and evolution, the physicochemical and mathematical bases of biological form and organisation, on 'rational taxonomy', the classification of biological forms based on the developmental process generating the forms, as well as the wider social implications of evolutionary theory; all in the inspiring company of Peter Saunders, and later, also Brian Goodwin.

Yet something was still missing. I still did not understand how catching the electron between the excited and the ground state could make life go round. A chance meeting with Fritz Popp in 1985 changed all that. Although I understood then almost not a word of his lecture, I was convinced what he said was very significant: that coherence held the key to living organisation. And so I plunged into quantum physics, with the help and encouragement of Fritz, who also invited me to work on light emission from living organisms in his laboratory. With immense patience and panache, he taught me quantum physics, taking me straight into the exotic world of quantum optics. Having got in at the deep end, I could do little else but swim to shore! Suddenly, everything begins to make sense.

When Brian Goodwin said to me: 'Why don't you write a book on what is life?' I thought, why not? A month later, I put pen to paper, and the first draft was complete by the time another month had elapsed.

This book is patterned, roughly, after Schrödinger's *What is Life?* (Cambridge University Press, 1944), and addresses the same question: can living processes be explained in terms of physics and chemistry? His preliminary answer, in the 1940s, is that the inability of the physics and chemistry of his day to account for living processes is no reason for doubting that living processes could be so explained. For, on the one hand, there has not been an adequate experimental investigation of *living* processes, and on the other, physics and chemistry are both evolving disciplines, and some day, they *may* just succeed in accounting for life.

Indeed, physics and chemistry have developed a great deal since Schrödinger's time. Whole new disciplines became established:

synergetics, non-equilibrium thermodynamics, quantum electrodynamics and quantum optics, to name but a few. There have already been several suggestions that the new physics and chemistry may be particularly relevant for our understanding of biological phenomena. I, for one, believe it is time to examine Schrödinger's question again, which provides a ready structure for this book.

I shall be ranging widely over the different physical disciplines already mentioned, starting from first principles; as well as the relevant physiology, biochemistry and molecular biology of cells and organisms. Those who expect details of molecular genetics and gene control mechanisms, however, will be disappointed. They should consult instead the numerous volumes of excellent texts that already exist. In *this* book, it is the bare-bones sketch that I shall be concerned with – the fundamental physical and chemical principles which are relevant for life.

At the risk of giving the story away, I shall say a few words on what this book is about. The first chapter outlines the properties of organisms that constitute 'being alive', and hence that which is in need of explanation. Chapters 2 to 5 show how a living system differs from a conventional thermodynamic machine. The organism's highly differentiated space-time structure is irreconcilable with the statistical nature of the laws of thermodynamics. And hence, the laws of thermodynamics cannot be applied to the living system without some kind of reformulation. The space-time structure of living organisms arises as the consequence of energy flow, and is strongly reminiscent of the non-equilibrium phase transitions that can take place in physicochemical systems far from thermodynamic equilibrium. Energy flow organises and structures the system in such a way as to reinforce the energy flow. This organised space-time structure suggests that both quasi-equilibrium and non-equilibrium descriptions are applicable to living systems, depending on the characteristic times and volumes of the processes involved. Hence, an appropriate thermodynamics of the living system may be a *thermodynamics of organised complexity* involving, among other things, replacing the concept of *free* energy with that of *stored* energy.

Thermodynamics has its origin in describing the transformation of heat energy into mechanical work. As shown in Chapters 6 to 9, the predominant energy transductions in the living system are instead, electronic, electric and electromagnetic, as consistent with the primary energy source on which life depends as well as the electromagnetic nature of all molecular and intermolecular forces. Furthermore, given the organised, condensed state of the living system, it is predicted that the most general conditions of energy pumping would result in a phase transition to a dynamically coherent regime where the whole spectrum of molecular energies can be mobilised for structuring the system, and for all the vital processes which make the system alive. Chapters 8 and 9 summarise experimental evidence for coherence in living organisms, some of the findings pushing at the frontiers of quantum optics and quantum electrodynamics. The relevance of quantum theory to coherence in living systems is treated in more detail in Chapter 10.

The summary of the enquiry suggests that organisms are *coherent* space-time structures maintained macroscopically far from thermodynamic equilibrium by energy flow. This has profound implications on the nature of knowledge and knowledge acquisition, as well as on the nature of time as it relates to issues of determinism and freewill, which are dealt with in Chapters 11 and 12. There, I try to show how, by following to logical conclusions the development of Western scientific ideas since the beginning of the present century, we come full circle to validating the participatory framework that is universal to all traditional indigenous knowledge systems the world over. This enables us to go some way towards restoring ourselves to an authentic reality of non-linear, multidimensional space-time as experienced by the truly participatory consciousness, who is also the repository of free will and coherent action.

I have been asked whether it is necessary to do the science before getting to the point, which is the validation of participatory knowledge. Why not just develop the 'rhetoric'? That would have defeated one of the main purposes of this work, which is to show how science can reveal in a precise way the deeper wonders and mysteries of

nature which are currently in danger of being totally obscured by the kind of superficial woolly misrepresentation that many people, especially the young, mistake to be 'new age philosophy'. Another motivation for writing this book is to show that science, when properly perceived, is far from being alienating and dehumanising. Instead, it is consonant with our most intimate experience of nature. To me, science is surely *not* about laying down eternal 'laws of nature' to dictate what we can or cannot think. It is to initiate us fully into the poetry that is the soul of nature, the poetry that is ultimately always beyond what theories or words can say.

This book is the most exciting thing I have ever written. I would like to dedicate it to everyone young or youthful who has ever looked upon the living process in wonderment. I cannot express my gratitude enough to all those already mentioned, who have both inspired and encouraged me in realising this work. Peter Saunders, as always, gives up much of his time to help me with the mathematics and the physics.

Very special thanks are due to my former colleagues, Oliver Penrose (Professor of Applied Mathematics and Theoretical Physics at the Open University, now at Herriot-Watt University, Edinburgh) and Kenneth Denbigh (Professor of Physical Chemistry and Principal at Queen Elizabeth College, London) for reading an earlier version of the entire manuscript, commenting in substantial detail, correcting errors in my presentation, and stimulating me to new levels of understanding. To my present colleague, Nick Furbank (Professor of English at the Open University), I owe the title of this book and much more: he read and gave me helpful suggestions on the penultimate draft, and restored my faith that the book will reach a wider readership, including those without any scientific training who nevertheless love the subject as much as I do. Comments, suggestions and corrections are also gratefully acknowledged from Ronald Pethig, R.J.P. Williams, Clive Kilmister, Geoffrey Sewell, Wolfram Schommers, Francisco Musomeci, T.M. Wu, K.H. Li, R. Neurohr, Konrad Kortmulder, Lev Belousov, Hansotto Reiber, Charles Jencks, Willis Harman, Lynn Trainor, Guiseppe Sermonti, Sheila Higham, Viven Thomas, and Katy Bentall.

Last, but by no means the least, I would like to thank my brother, Li Poon and my son Adrian Ho for giving me their support as well as valuable comments and suggestions. The shortcomings which remain are all my own.

Milton Keynes
July 1993