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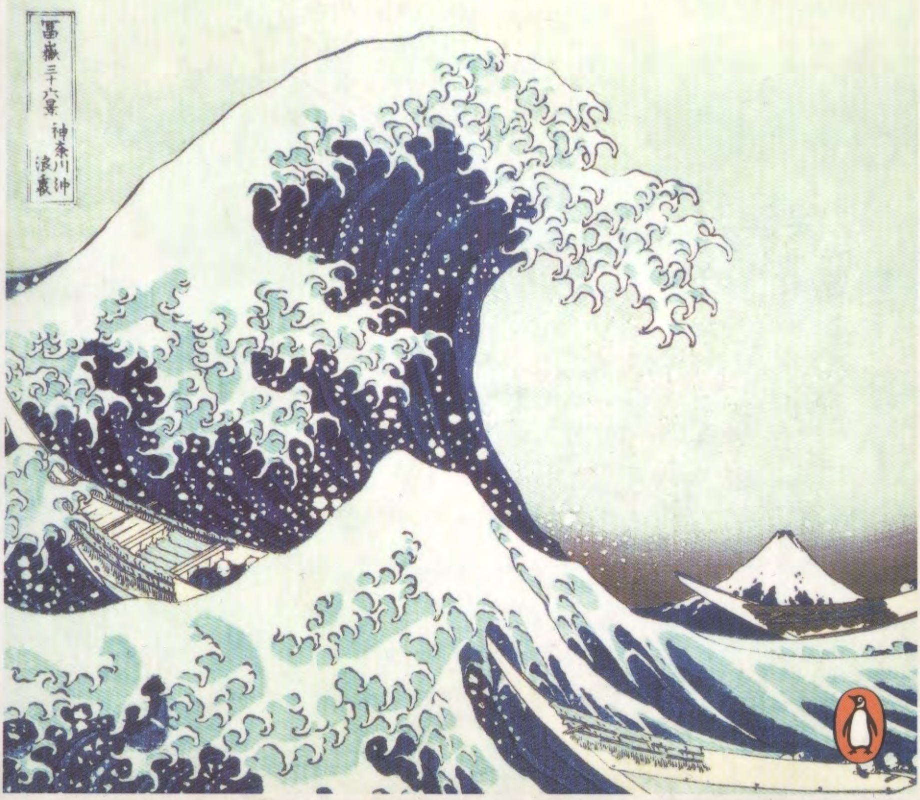
JOHN GRIBBIN

From the bestselling author of *In Search of Schrödinger's Cat*

DEEP SIMPLICITY

Chaos, Complexity and the Emergence of Life



The little things that make big things happen ...

The world around us can be a complex, confusing place. Earthquakes happen without warning, stock markets fluctuate, weather forecasters seldom get it right – even other people baffle us. How do we make sense of it all?

In fact, John Gribbin reveals, our seemingly random universe is actually built on simple laws of cause and effect that can explain why, for example, just one vehicle braking can cause a traffic jam; why wild storms result from a slight atmospheric change; even how we evolved from the most basic materials. Like a zen painting, a fractal image or the pattern on a butterfly's wings, simple elements form the bedrock of a sophisticated whole.

The first book to synthesize chaos and complexity theory for the perplexed, *Deep Simplicity* brilliantly illuminates the harmony underlying our existence.

'What makes *Deep Simplicity* different from other books on complexity theory is that Gribbin ... goes back to the fundamentals'
Daily Telegraph

'Gribbin takes us through the basics with his customary talent for accessibility and clarity'
Sunday Times

'One is left feeling even more filled with admiration for science and delight at the world it investigates'
Financial Times

'Gribbin breathes life into the core ideas of complexity science' ***Nature***

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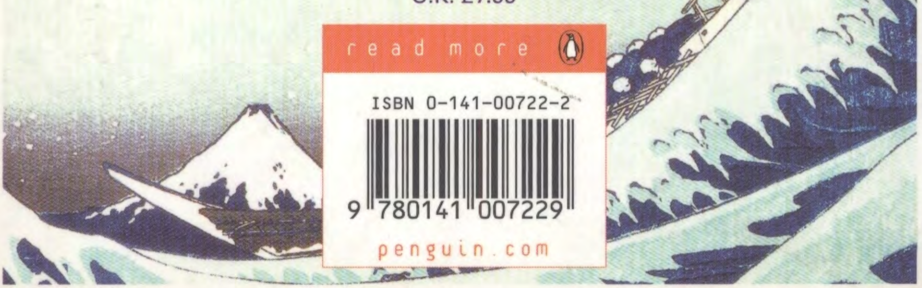

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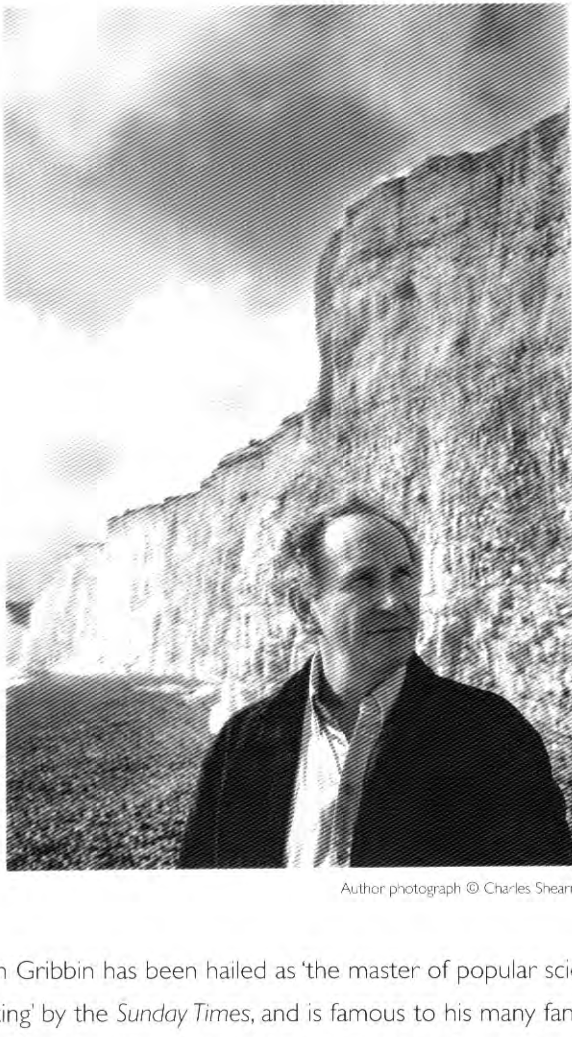

Author photograph © Charles Shearn

John Gribbin has been hailed as 'the master of popular science writing' by the *Sunday Times*, and is famous to his many fans for making complex ideas simple. He is the author of numerous books, many written with his wife, Mary Gribbin, and says that his aim is to share his sense of wonder at the strangeness of the universe with his readers. He also enjoys working on science-fiction stories in his spare time, and does most of his writing in a shed in his back garden.

INTRODUCTION
The Simplicity of Complexity

The world around us seems to be a complex place. Although there are some simple truths that seem to be eternal (apples always fall to the ground, not to the sky; the Sun rises in the east, never in the west), our lives, in spite of modern technology, are still, all too often, at the mercy of complicated processes that produce dramatic changes out of the blue. Weather forecasting is still as much an art as a science; earthquakes and volcanic eruptions strike unpredictably, and seemingly at random; stock-market fluctuations continue to produce boom and bust with no obvious pattern to them. From the time of Galileo (in round numbers, the beginning of the seventeenth century) science made progress – enormous progress – largely by ignoring these complexities, and focusing on the simple questions, looking to explain why apples fall to the ground, and why the Sun rises in the east. Progress was so spectacular, indeed, that by about the middle of the twentieth century all the simple questions had been answered. Concepts such as the general theory of relativity and quantum mechanics explained the overall workings of the Universe on the very large and very small scales respectively, while the discovery of the structure of DNA and the way in which it is copied from generation to generation made life itself, and evolution, seem simple at the molecular level. And yet, the complexity of the world at the human level – at the level of life – remained. The most interesting question of all, the question of how life could have emerged from non-life, remained unanswered.

It is no surprise that the most complex features of the Universe, which proved most reluctant to yield to the traditional methods of scientific investigation, should exist on our scale. Indeed, we may be the most complex things there are in the Universe. The reason is that on smaller scales entities such as individual atoms behave in a relatively simple way in their one-to-one interactions, and that complicated and interesting things are produced when many atoms are linked together in complicated and interesting ways, to make things like people. But this process cannot continue indefinitely, since if more and more atoms are joined together, their total mass increases to the point where gravity crushes all the interesting structure out of existence. An atom, or even a simple molecule like water, is simpler than a human being because it has little internal structure; a star, or the interior of a planet, is simpler than a human being because gravity crushes any structure out of existence. And that is why science can tell us more about the behaviour of atoms and the internal workings of the stars than it can about the way people behave.

As the simple problems yielded to investigation, it was natural that some scientists should try to tackle the more difficult puzzles associated with complex systems. As we shall see, although some valiant individual assaults on these puzzles had been made earlier, it only really became possible to begin to understand the workings of the world on the complex human scale in the 1960s, with the advent of powerful and fast (by the standards of those days) electronic computers. These new developments began to emerge into the awareness of a wider public in the middle to late 1980s, with the publication first of the now classic book *Order out of Chaos*, by Ilya Prigogine and Isabelle Stengers, and then of James Gleick's *Chaos*. At the time, I was busily writing about the great triumphs of the old science, and although I occasionally tried to get to grips with the ideas of chaos and complexity, I found that doing so made my head hurt, so mostly I kept my distance. But after about ten years of waiting either for chaos theory to go away or for someone to write a book explaining it in language I could understand, I decided that if no one else was going to explain it in clear language, then I would have to. Which meant that I had to read everything I could find on the subject and try to understand it myself. It was while doing this that I discovered that it wasn't so difficult after all. Both relativity theory and quantum theory were regarded, when new, as ideas too difficult for anyone except the experts to understand – but both are based on simple ideas which are intelligible to the lay person willing to take the mathematics on trust. I ought not to have been surprised to find that the same is true of chaos and complexity – but I was, and I clearly recall the moment when I finally got the message about what it was all about. As I understood it, what really mattered was simply that some systems ('system' is just a jargon word for anything, like a swinging pendulum, or the Solar System, or water dripping from a tap) are very sensitive to their starting conditions, so that a tiny difference in the initial 'push' you give them causes a big difference in where they end up, and there is feedback, so that what a system does affects its own behaviour. It seemed too good to be true – too simple to be true. So I asked the cleverest person I know, Jim Lovelock, if I was on the right lines. Was it really true, I asked, that all this business of chaos and complexity is based on two simple ideas – the sensitivity of a system to its starting conditions, and feedback? Yes, he replied, that's all there is to it.

Now, that's a bit like saying that 'all there is' to the special theory of relativity is that the speed of light is the same for all observers. It is true, it is simple, and it is easy to grasp. Nevertheless, the complexity of the structure built on that simple fact is staggering, and needs some mathematical knowledge to appreciate it fully. But I knew from experience that I could explain the essence of relativity to people with no background in science, and the realization that there were similar simple truths underpinning chaos and complexity gave me confidence to try to do the same in that area. The result is in your hands, an attempt to take the obvious step of trying to explain chaos and complexity the simple way, from the bottom up – for everybody. The great insight is that chaos and complexity obey simple laws – essentially, the same simple laws discovered by Isaac Newton more than three hundred years ago. Far from overturning four centuries of scientific endeavour, as some accounts would lead you to believe, these new developments show how the long-established scientific understanding of simple laws can explain (although not predict) the seemingly inexplicable behaviour of weather systems, stock markets, earthquakes, and even people. As we hope to convince you, the study of chaos and the emergence of complexity from simple systems is now on the brink of explaining the origin of life itself. In a phrase attributed to Murray Gell-Mann, but echoing the speculation of Richard Feynman quoted at the front of this book, the complicated behaviour of the world we see around us – even the living world – is merely 'surface complexity arising out of deep simplicity'.[1] And it is the simplicity that underpins complexity that is the theme of this book.

John Gribbin,
January 2003

1. Quoted by, for example, Roger Lewin, in *Complexity*.

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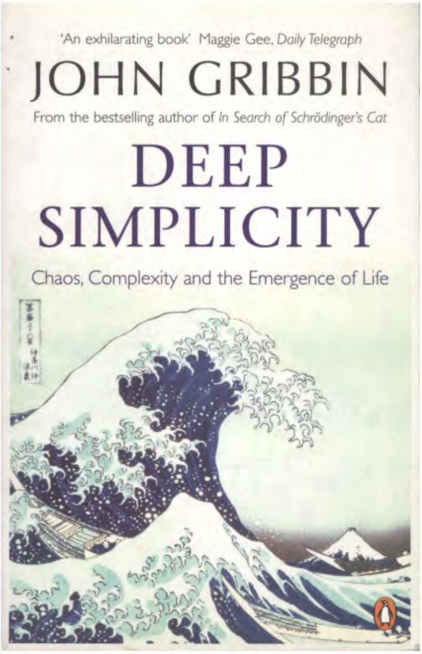
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