The science of everything

The emperor's new theory

A self-published book is being touted as the greatest step since Newton. Is it?

A New Kind of Science. By Stephen Wolfram. *Wolfram Media; 1,197 pages; $44.95 and £40*

EXTRAORDINARY claims demand extraordinary proof, and the claims made by Stephen Wolfram, a computer scientist, in his new book are extraordinary indeed. "A New Kind of Science" professes to offer an entirely new way of looking at the world. At its heart is the notion of modelling physical phenomena in terms of simple computer programs, rather than complicated mathematical equations. Mr Wolfram unashamedly compares the potential impact of his work to that of Sir Isaac Newton's "Principia Mathematica", and suggests that his discoveries can answer long-standing puzzles in mathematics, physics, biology and philosophy, from the fundamental laws of nature to the question of free will. Can his book possibly live up to such claims?

"A New Kind of Science" is an unusual work, quite apart from what it says. Mr Wolfram, a British-born prodigy who published his first scientific paper at 15, won a MacArthur genius grant at 21 and then made a fortune in the software business, exercised total control over the project. It is published by his own media company, making him author, editor and publisher. It is nearly 1,200 pages long and contains hundreds of intricate illustrations, generated by Mr Wolfram from his own software. It is the product of more than ten years' work, during which Mr Wolfram avoided the scientific community, lived as a recluse and ran his software company via occasional video-conference calls. Not surprisingly, the result is self-indulgent in places: Mr Wolfram lists every model of computer and programming language he has used since childhood, and estimates that while writing the book, he typed 100 million keystrokes and moved his computer mouse more than 100 miles.

None of which bodes well for the book's content. Yet publication has been anticipated in some quarters for years, and that message—that the universe is best understood through computing, rather than traditional mathematics—has struck a chord with the Internet crowd. "A New Kind of Science" quickly became an Amazon bestseller. Does it merit the hype?

Can doesn't mean must

Mr Wolfram's book grew out of his research into cellular automata. These are simple computational systems that can be rendered as rows of coloured squares on graph paper, and are governed by simple rules that specify how the colours of each row of squares depend on the colours of the previous row. The properties of cellular automata are easily explored using a computer, which can produce thousands of rows of output in the blink of an eye. It hardly sounds like the basis for a new science, but in 1984 Mr Wolfram came across one cellular automaton, known as Rule 30, that produced chaotic, unpredictable output despite the simple rules that govern its operation. This was Mr Wolfram's Eureka moment: it suggested to him that complex systems in nature—be they weather systems, turbid fluid flow, a zebra's stripes or the human mind—might all be governed by small and simple sets of rules.

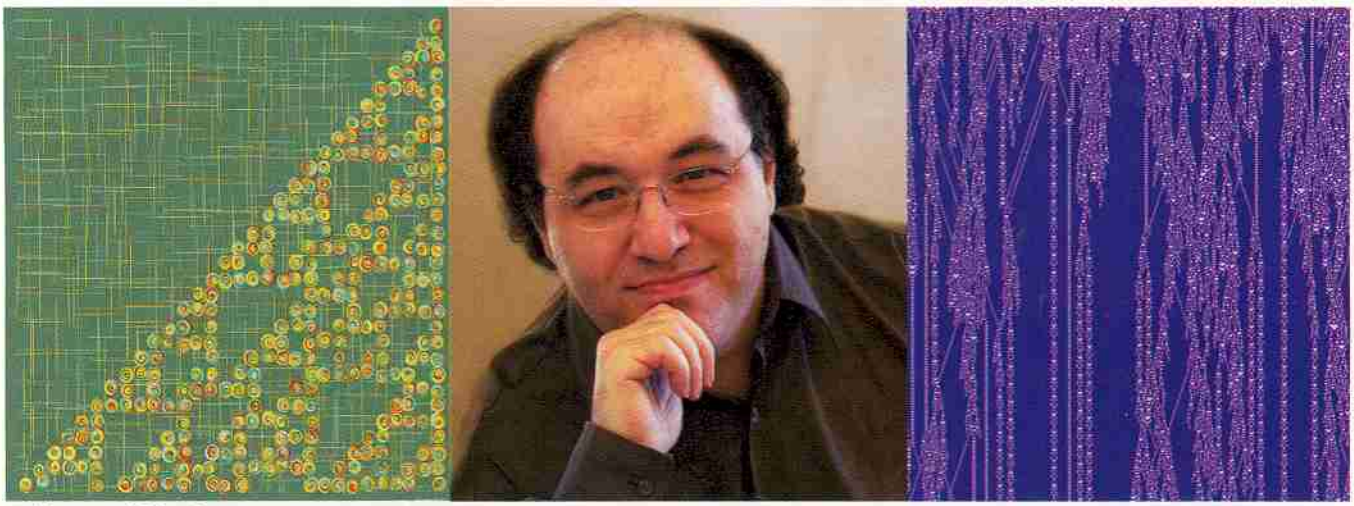
The first few chapters of his book explore this possibility in detail, using dozens of examples of cellular automata. The explanations are fascinating and wonderfully lucid. Mr Wolfram shows with countless examples how apparently simple systems can give rise to extraordinarily complex behaviour.

Having settled that beyond question, he then makes a vast speculative leap. Because complex behaviour is abundant in nature and because it can be produced by simple systems akin to cellular automata, that, he asserts, is how all complex behaviour must be produced. *Et voilà*, he has found the secret of the universe: simple computation rules can yield structures that resemble trees, shells and snowflakes; that, Mr Wolfram tells us, is therefore how nature generates everything.

Mere equations, he observes, cannot capture such complexity, whereas simple computational rules can. To the obvious objection that systems that are superficially similar might have radically different structural features, he answers that cellular automata can still be useful models, even if the underlying mechanisms of natural phenomena are totally different.

This reply is not convincing. In existing science, the equations of a good theory are taken to represent physical reality because they can be used to make predictions. Chaotic cellular automata cannot. No doubt Mr Wolfram would say it is unfair to judge his new science by the standards of the old. But allowing that would mean abandoning the Galileo test: science's explanatory power and authority stem from its ability to make testable predictions. Otherwise theory is nothing more than post-hoc speculation.

That said, one of the most impressive ▸▸



Wolfram and friends

parts of the book is Mr Wolfram's guess that the universe might, in fact, be a giant cellular automaton at the subatomic level. His elaborate model cleverly accounts for physical phenomena such as causality, relativity, and the finite speed of light. Similarly, his demonstration that a cellular automaton known as Rule 110 can operate as a universal computer—the simplest possible computer, but one that can be used to simulate an arbitrarily complex machine—is a tour de force.

Yet these triumphs are undermined by Mr Wolfram's insistence on trying to use his computational approach to explain absolutely everything. Scientists in many fields, from quantum physics to cosmology, like to think that the secret of the universe lies in their particular fief. Recent books have suggested that multiple universes or quantum gravity can explain consciousness or free will. This kind of speculation is usually kept for the final chapter. Mr Wolfram's entire book is shot through with it. He sees the history of science as a prelude to his years at the keyboard, and the computer as powerful an instrument of discovery as the telescope or microscope. He also seems to want to take credit for complexity theory itself.

There's no short cut

One last act of daring is Mr Wolfram's principle of computational equivalence, by which he lumps together all complex phenomena as equally complex manifestations of the same underlying rules for cellular automata. All unpredictable processes, he argues, from water going down a plughole to human consciousness, are computationally equivalent. He notes that great scientific breakthroughs in the past have undermined humanity's belief that it is special. But that does not mean that every such theory is correct.

Had it been shorter and better focused, Mr Wolfram's book would have been more convincing. It feels as if he wrote it in a vacuum, and the hand of an editor is sorely missed. In fairness, these faults are more irritating than decisive. Newton believed all sorts of odd things. A book with an interesting new theory does not have to be right for it to be worth reading, and Mr Wolfram's book certainly is that. It will provoke debate and experiment. Parts of it might one day be integrated into tested physical theory. Despite Mr Wolfram's bold attempt at a short-cut, that is how science of the old-fashioned kind works. ■