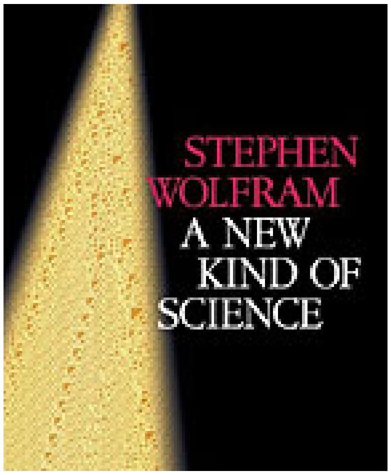
A New Kind of Science: Book Review

A New Kind of Science, Stephen Wolfram. Wolfram Media, Inc., 2002. Hardcover, 1197 pages + index. ISBN 1579550088. $44.95.



As soon as I had volunteered to write this review, I said to myself "Why did you *do* that?" Yes, I have the book and have read it. But there are dozens if not hundreds of reviews readily available on the Web. And I am not qualified to evaluate most of the far-reaching claims in the book. I can, however, comment on aspects of the book that may be of interest to weavers and designers with a mathematical bent.

I'll start with some general comments about the book and its author. The two cannot be separated because the book is an exposition of the author's research and personal opinions.

Stephen Wolfram: Wolfram was a child prodigy. He published his first journal article at the age of 15 and got his Ph.D. in theoretical physics at age 20 from CalTech.

After he got his degree, he taught at CalTech, had a stint at Princeton's Institute for Advanced Studies, and held other academic positions. Along the way, he wrote *Mathematica*, a symbolic mathematics program [1]. The success of *Mathematica* made him wealthy and allowed him to pursue his research interests independently.

Wolfram is undeniably brilliant. Richard Feynman, a Nobel Laureate in physics, called him "astonishing". Wolfram also has been called the smartest scientist on the planet. Wolfram's opinion of himself is similar. He is self-aggrandizing and described by a longtime friend as having "an appalling lack of humility".

A New Kind of Science: His book, the result of over a decade of work in virtual isolation, shows both his brilliance and his high opinion of himself. It is written in the first person and littered with phrases like "what I have shown in this book". The book has no bibliography and there are few credits to others' work.

The book contains hundreds of illustrations, although none in color. Some of the diagrams and pictures are displayed with novel and interesting graphic techniques.

The book is written for the layman. There are no formulas or mathematics in the body of the book (there is, however, an extensive, more technical section of notes).

He touches on a wide range of subjects ranging from particle physics to possible extraterrestrial intelligence.

Basically, Wolfram disparages most of modern science and mathematics. Little is sacred, from the second law of thermodynamics to natural selection.

The underlying theme that is the basis for his claims is the observation that complex objects can be created by the repeated application of simple rules. Wolfram believes that almost all complex natural phenomena have very simple origins — everything from the underlying structure of space and time to human intelligence. And he equates all of this to simple programs.

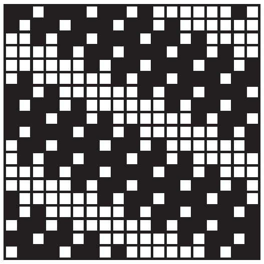
Another View of the Book: The book can be viewed in a different way by persons interested in mathematics and patterns as they relate to weaving and similar subjects.

The book is replete with examples of formal systems and patterns that can be created by them. Three examples follow. I'll skip details in favor of conveying the basic ideas.

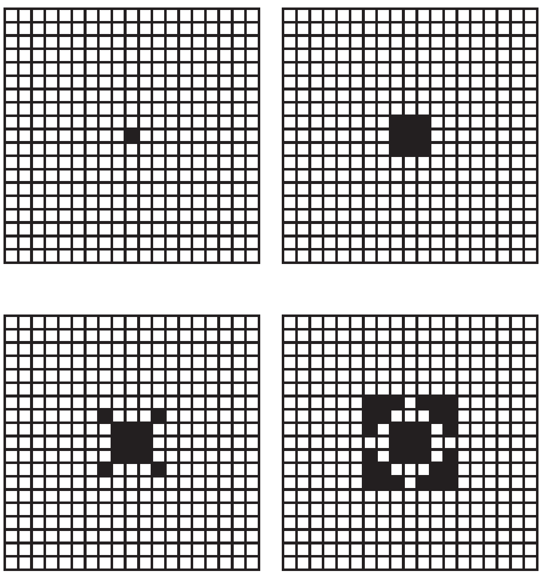
Cellular Automata

Much of the book is devoted to cellular automata and the patterns they can create. Cellular automata are arrays of cells whose states change in parallel at discrete time steps, depending on the states of their neighbors. Wolfram deals primarily with one-dimensional cellular automata, but two-dimensional ones are more interesting for pattern design.

A two-dimensional array of cells with two states, black and white, can be thought of as a drawdown, and vice versa:



One state-transition rule changes a cell to black if exactly one of its immediate eight neighbors (horizontal, vertical, and diagonal) is black but leaves its color unchanged otherwise. Here is the progression of a 19×19 automata starting with all cells white except a black one in the center:



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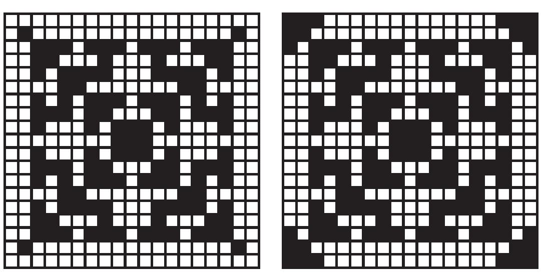


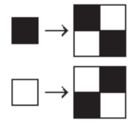
Interestingly, the last state is stable; all subsequent patterns are the same.

Using different rules and different initial states, an endless number of patterns can be created.

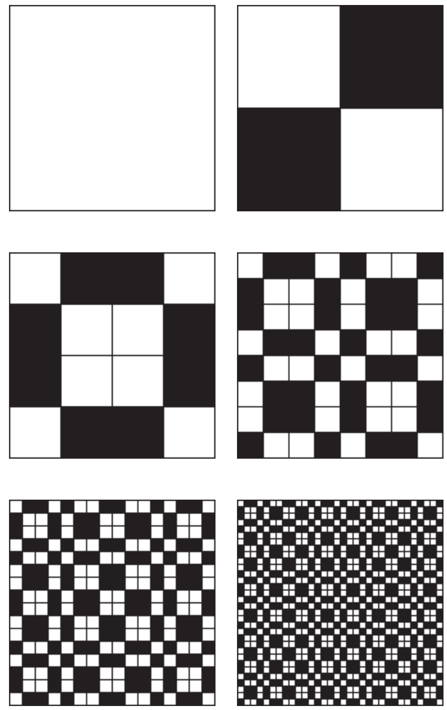
Block Substitution

In block substitution, at each iteration every cell in a pattern is replaced by a block of cells, according to its color.

For example, if the substitution rules are



the sequence of patterns starting with a single white cell is:



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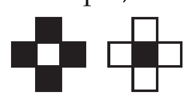
Again, there are endless possibilities.

Constraint Systems

In constraint systems, every cell must have a neighborhood that corresponds to a constraint in a given set.

Suppose, for example, the constraints are:



That is, every white cell must have four adjacent black cells and every black cell must have four adjacent white cells. The only patterns that satisfy these constraints correspond to plain weaves.

Not all constraint sets are satisfiable — some constraint sets are inconsistent. Only 171 patterns are needed to satisfy all possible constraint sets. Some patterns are familiar from weaving, like twills. A few patterns are structurally unweavable. But many are interesting candidates for new weave designs.

An interesting aspect of constraint systems is that while it is straightforward to determine the constraint set for a given pattern, it is not straightforward to find patterns that satisfy a given constraint set; that problem is computationally intractable. It might be interesting, for example, to find all patterns with the same constraint set as a given twill, but there is no efficient way of doing so.

Conclusions

This book, despite its many flaws, truly is amazing. On the one hand, it contains far-reaching, and potentially revolutionary, deep intellectually content. On the other hand, it is a fascinating "picture book".

For the mathematically inclined pattern designer, it is a gold mine of ideas.

Reference

1. *The Mathematica Book*, Stephen Wolfram. Wolfram Media and Cambridge University Press, 3rd. edition, 1996.

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