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REVIEW

Chaos: Making a New Science. By J. GLEICK. Viking, 1987. 352 pp. $19.95 (hardback); Cardinal, 1988. £5.99 (paperback).

For a field of research which has rapidly grown and spread into nearly all aspects of scientific research in less than two decades, chaos does not lend itself to a simple review. But, this book manages to capture the advances of chaos through meteorology, astronomy, biology, economics, thermodynamics, and mathematics in a very readable, non-technical way. The book leads one through the moments of discovery of a number of scientists and mathematicians, illustrating the exciting, rewarding, but also unnerving and even frustrating paths to discovery these people took.

The book begins with Edward Lorenz's discovery of chaos in a simple, twelve-degree-of-freedom, toy model of weather. By accident, Lorenz found that two closely matched initial conditions eventually diverged, producing two entirely different long-range forecasts. It is concluded, by analogy, that the actual weather is inherently unpredictable, since a small perturbation – it is believed – will soon amplify to such an extent as to dash all hopes of weather forecasting beyond one week. The author suggests that even an ultra-powerful computer capable of computing the governing equations on a grid with one-foot spatial resolution and fed with perfectly accurate observed initial data would give a useless forecast beyond one week. The unknown data *between* grid points is the source of the perturbation. Hence, a butterfly in China will significantly alter the course of major weather systems in a week or so.

Or will it? Is the weather really that sensitive? Have the major weather forecasting research centres not heeded the warning from related work in chaos? There is a critical assumption made in the above arguments. That is, nothing essentially different happens when one passes from a model with twelve degrees of freedom to one with millions or billions.

At present, chaos is being closely followed by a second scientific revolution, one that is concentrating on the curious behaviour found only in large systems, that of large-scale structure or collective motion. In weather, specifically, and in fluid dynamics, generally, researchers have come to recognize that large-scale structures play a leading, almost exclusive role. Large-scale structures control the motion of small-scale, disorganized, one might say chaotic parts of a flow. Many who model the weather on supercomputers today would argue that the weather forecasts produced are actually surprisingly good, given the great inhomogeneity and unreliability of the input data.

Perhaps large systems actually boil down to a few degrees of freedom, so that the problem of large-scale structure is ultimately a simple consequence of chaos. The author states: 'quite simple mathematical equations could model systems every bit as violent as a waterfall'. Is this view representative of present scientific thinking? If many large systems do have at their root very simple mathematical equations, the consequences would be astonishing (i.e. modelling the weather on one's personal computer). Short of this, there is much exciting scientific research yet to be done to understand large-scale structure.

In summary, this book presents an entertaining history of a remarkable, almost uncontainable scientific development. One can feel the excitement and drama of discovery through the words of the scientists who made great advances. In this way, the public has been allowed to share and appreciate the scientific process. But the book extrapolates the results of chaos too far, leading the public to believe, for example, that weather forecasting will not improve significantly from better data and models. Many scientists do expect improvements, and hope to continue to win the support necessary to bring about these improvements.

D. G. DRITSCHEL