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Making a New Science

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In any case, for military and civilian readers alike, Graham's large book, with its panorama of Soviet scientific research and accomplishments, stands as required reading for all those who share interest in the science, philosophy, and culture of the great nation to the east, some of whose leaders at least today incline to the belief, hitherto unthinkable, that their national interests may coincide to some degree with our own.

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Gleick, James. *Chaos: Making a New Science*. New York: Viking, 1987. 352pp. $19.95

In the last twenty years mathematicians and scientists have come to recognize that much of what goes on in nature is not as random and noisy as previously thought, but contains beautifully and subtly intricate behavior which appears to be chaotic only at first look. James Gleick of the *New York Times* has written a remarkable and orderly book about this disorderly business. He has used his considerable talent to present the fundamental concepts and applications of chaos in ways which the nonmathematical reader will find exciting and stimulating.

There are concepts and techniques in this new field that may well have application to both the development of naval hardware and to an understanding of the complex processes of naval warfare. Indeed, the Navy has supported some considerable research into the mathematics of chaos.

Through the early 1970s, much of the observable variation in the world around us was assumed to be random noise of no significance for prediction. When Edward Lorenz began modeling the earth's atmosphere and weather on an early digital computer at MIT, he found that he got rather dramatic changes in the resulting climate forecasts from apparently insignificant changes in the initial conditions.

Lorenz' work, along with similar observations in other fields of natural science such as insect population growth, led to a serious challenge to traditional scientific intuition. That intuition had held that, over the long term, a steady state will evolve in nature. Chaos was not an acceptable answer. Not so in the things studied by Lorenz and the others. They began to find many situations where orderly disorder prevails over the long term. Plant and animal populations, while appearing to change slowly but constantly, might in fact be constantly and forever alternating between two or more short-term stable states. This sort of bifurcation was quite unrecognized until the tools of the mathematics of chaos became available.

As Gleick describes it, the mathematics of chaos is itself a wonderfully chaotic subject with many trails and threads leading to new and intriguing ideas. One that has received a good bit of popular attention is the study of fractals, those ornate, almost rococo, shapes that describe the boundaries between initial conditions or states leading to chaotically different outcomes. Fractals often have an ethereal beauty of their own as Gleick illustrates with some elegant computer generated pictures in his book.

The significance of fractals lies in their repetitiveness at smaller and smaller scales—as the resolution increases, the same pattern appears again and again, albeit in smaller size. In mammals, blood vessels, nerves, and bronchi branch and branch again in fractal like ways. Some geneticists have speculated that the DNA code may contain a simple fractal key for these rather than a specific guide for each branch and junction.

Another intriguing fractal that may have some naval application is the Cantor set. Imagine a line of fixed length, remove the middle third, and then remove the middle third of each of the remaining thirds. If this process is continued infinitely, it will generate "a strange dust of points, arranged in clusters, infinitely many yet infinitely sparse." As it happens, study of this fractal set has revealed some important insights into the occurrence and behavior of errors in the transmission of digital information.

Turbulence has frustrated mathematicians, physicists, and engineers for centuries. Why should the orderly flow of air over a wing or water in a pipe suddenly change to swirling, turbulent instability? Why does a flag flap continuously rather than holding a steady position in the breeze? On his deathbed, the great physicist Heisenberg is supposed to have said that he would have two questions for God: "Why relativity and why turbulence? He then said: "I really think He will have an answer only to the first question."

Gleick describes some simple but immaculate experiments by Libchaber and his colleagues to examine the onset of turbulent flow. The mathematics of chaos gave them new insight into the problem and can be expected to lead to more efficient designs for such practical things as wings and hydraulic systems.

The mathematics of chaos is an unusual subject for students, alumni and friends of the Naval War College to pursue, but it is well worth the reading. The subject has fascinating potential for research in international and military affairs. Certainly the impact of the mathematics of chaos on turbulent flow and weather will be of eventual use to planners of naval warfare. One could happily speculate on the parallels between the green and white earth solutions and the fragility of the difference between peace and war or even the difference between winning and losing a battle!

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Keegan, John. *The Mask of Command.* New York: Viking, 1987. 368pp. $18.95

John Keegan's *Mask of Command*, a study of Alexander, Wellington,