Chaos: Making a New Science *by James Gleick*
(Cardinal, London, 1989) pp. 352, $14.99, ISBN 0-7474-0413-5

Every now and then a book comes along which catapults the ideas of a relatively unknown development in science to the world. *Chaos* is such a book. James Gleick, the science reporter for the *New York Times,* has chronicled the generation of a 'revolution' in the physical sciences that has gathered significant momentum in the last decade or so. To readers of his reports, or of publications such as *Scientific American* and *Nature,* the emergence of 'chaos' as a respected area of scientific endeavour would not have slipped by unnoticed. But to many of us who are students of the social sciences, the book is a magnificent exposition into an almost unimaginable universe.

Chaos describes a methodology that seemingly developed independently among those scientists who were perplexed by unexplained phenomena in their own fields and who were dissatisfied with orthodox approaches which failed to explain them. Some of these scientists wondered about the nature of dynamic systems; one was concerned with the geometry contained within the background noise of data transmission; another began to see regularities in the behaviour of turbulence in fluids; whilst a biologist discovered some interesting effects that could be generated with simple mathematical models of population growth and decline. The very shape of clouds was being pondered. Physiologists believed that unexplained death could be explained through "a surprising order in the chaos" of the human heart (p. 4). Even the supposedly immutable second law of thermodynamics did not escape significant qualification. However, such phenomena were not considered the 'proper' course of study and did not attract grants that went to the more traditional areas of study, the highly specialised areas of science. The growth of the science of chaos is a story of a struggle against the establishment.

To take one example of what has been found: it has long been believed that laboratory experimentation was a reliable method by which to test a theory in physics. But experiments were rarely perfect. There was always some unavoidable 'noise' that occurred, but it was considered insignificant and as such could be ignored, being the result of the inability to construct a perfectly closed environment. The noise and fluctuations were generally random and in fact, when measured, proved to be so. Thus such phenomena were ignored, with scientists considering them as abberations too complex for mathematical exposition. Where traditional scientific study stopped, chaos theory began. Robert May, an Australian by birth, was a theoretical physicist turned population biologist who attempted to model the growth and decline of species numbers. He was confounded by the tendency for populations to fluctuate and often grow in a random manner, never reaching a steady-state or equilibrium. Using the very simplest of dynamic models with one fixed parameter, May found that, when this parameter was at low levels, a steady-state would be reached. At a higher level, the population fluctuated between bounds, but when the parameter was adjusted to even higher levels, the result was a mapping of the population over time that was seemingly random: it was chaotic. Suddenly, however, the chaos could disappear and a steady-state reappear. But this would not last long and the chaos would emerge again. The extraordinary thing was that a seemingly simple model would generate a rich, complex, and discontinuous dynamic time path.

May's findings were independently replicated across the world and across disciplines. It seemed that the chaotic features stemmed from the nonlinearity of the models used. Traditionally, science — in particular physics — paid attention to linear proeprties for the acceptable reason that nonlinear models did not yield simple solutons and did not lead to neat, stable equilibria. In the real world, however, nonlinearity is the norm and the flood of examples in *Chaos* emphasises this. It would seem that the techniques of chaos can explain many wonders of nature from Jupiter's Red Spot to irregularities in fluid dynamics. Chaos has even developed to the extent where a new universal constant has been discovered. The distinguishing feature of chaos is that is appears almost everywhere — in the smoke from a fire, the effervescence of champagne, the rattle and hum of an engine, the shape of leaves, the world of everybody.

As would be predictable, my own field of economics is not immune from the application of chaos theory. Articles appeared as early as 1963 by chaos pioneers such as Benoit Mandelbrot and Steven Smale examining the fluctuations in cotton prices and the stability of general equilibrium. Other studies have looked at stock prices but have not found any chaotic regularities to date. Economic time series have long been characterised by seemingly random behaviour around a trend. Even where good statistical fits have been found (such as with aggregate consumption functions), good predictions have not emerged. The lack of success in explaining economic data has led to a school of economics which, using efficient market or rational expectations hypotheses, has attempted to explain the randomness as consistent with the behaviour of rational agents. However, the problem with this form of analysis is that it is virtually impossible to formulate any policies to improve the performance of the economy and thus, it is not surprising that hardly any policies emerged from this school. Chaos suggests that such effects may not be random and hence they are predictable and political.

Physics has historically played a dominant role in the development of orthodox economics. The notion of stable market equilibrium (associated with Marshall and Walras) came from Newtonian mechanics, and economists have adopted the mathematical tools of physics, differential and difference equations for example, in order to find and analyse the equilibria in the economy. Chaos theory, however, suggests that dynamic adjustment paths can have a role in determining final equilibria in the long run and one is reminded of the warnings of Keynes regarding policy formulation:

> . . . this long run is a misleading guide to current affairs. In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us when the storm is long past the ocean is flat again.[1]

Meterologists have long had the dream of being able to predict the weather perfectly, just as economists have aspired in the field of economics. However, when Edward Lorenz set up a simple set of nonlinear differential equations to model the global weather system, he abandoned the dream of weatherpeople. His simple system generated a complex time path that was seemingly random, but it was totally dependent upon initial conditions. If he merely set the initial parameters to a different level at the seventh decimal place, the time path that emerged was unrecognisable. The data could never be available to map the climate in a nonlinear world.

Such a result may spell the end for the economist's dream for almost the same reasons. Economic data are notoriously unreliable even to the naked eye. Thus, if the economy were a nonlinear system, then economists could never know with enough accuracy what present conditions were in order to predict the future perfectly. Near enough is not good enough in a nonlinear world, for the end result is chaotic. It has long been recognised that nonlinearities exist in the real economic world. Indifference curves may not be perfectly convex, production functions may have areas of increasing and decreasing returns, demand curves can have kinks and supply curves can bend backwards. These realities have, previously, been ignored, and like the physical sciences, techniques of linear approximation have been used to proceed regardless. Such methods were considered acceptable if the system was never far from equilibrium and only relatively small changes in the data occurred. The significance of chaos, however, is that restricting analysis to the margin does not solve the problems of nonlinearities.

New mathematical tools are now becoming available which allow analysts to test whether a function is an unstable linear function with stochastic results or a deterministic nonlinear function which possesses chaotic dynamics, and some eminent economists have begun to look at the possibilities of chaos.[2] Nevertheless, whereas chaos theory could be the liberator for the predictions of many of the physical sciences, for social sciences, such as economics, the techniques it spawns may signal the end for a mathematical approach in these areas. Even if the perfect data were available, in social sciences there are so many factors affecting the behaviour of individuals that the possibilites for discovering the appropriate nonlinear equations are bleak. The method of a relatively isolated experiment with few free parameters (such as a dripping faucet) is not available in the social sphere.

Of course, to some schools of economics the above observations may come as no surprise. The fields of institutional and information economics have been built on the basis that human behaviour is not capable of precise mathematical dissection. They recognise that the real economy is not a mechanical automaton but a plethora of institutions, organisations and diverse relationships the nature of which cannot be found in simple equations. The chaos theorists echo similar sentiments in the physical sciences: "When you think about a variable, the evolution of it must be influenced by whatever other variables it's interacting with. Their values must somehow be contained in the history of the thing. Somehow their mark must be there" (p. 266). Arrow expressed similar views in relation to the development of organisations when he stressed the importance of history.[3] Thus, if chaos theory examines evolution rather than the simple equilibrium, the institutional and information economists see their own images.

Chaos is important reading for it has an exciting message of hope and a new direction. Even for economics, where chaos may mean the end of strict mathematical analysis, it may signal the beginning for peripheral areas of economics (such as the economics of institutions and information) to move to centre stage.[4] For, like chaos theory, these areas of economics have formed from a more generalist (as opposed to specialist) approach, with many independently developed concepts. If tools can develop in chaos theory for a systematic research programme attacking so many problems, why not the same for information economics? To paraphrase Victor Hugo:

> there is one thing stronger than all the armies in the world; and that is an idea whose time has come.

It is a quality of enduring books that they tend to be entertaining as well as thought provoking. *Chaos* reads like an epic novel, with as many twists, turns and tragedies as a thriller. As the developments unfold, the reader is left dumbfounded and disbelieving of what has just been read. James Gleick adds to the tension and excitement with a lucid style devoid of any technicalities that may deter the layperson. The diagrams and illustrations and their complexity leave the reader seeing them as works of art. And to fill in the gaps there is a plethora of anecdotes and stories describing the context in which chaos was born.

REFERENCES

1. J.M.Keynes, *A Tract on Monetary Reform*, reprinted as Volume IV of *The Collected Works of John Maynard Keynes*, Macmillan, London, 1971.
2. W.J. Baumol and J. Benhabib, 'Chaos: significance, mechanism, and economic applications', *Journal of Economic Perspectives*, 3, 1, 1989, pp. 77-105.
3. K.J. Arrow, *The Limits of Organization*, Norton, New York, 1974, p. 49.
4. Gleick's book has a significant discussion of information theory.

Joshua Gans
University of Queensland

And The Band Played On: Politics, People and the Aids Epidemic *by Randy Shilts*
(Penguin, Harmondsworth, 1987) pp. xxiii + 630, paper $24.95, ISBN 0-14-011130-1

Randy Shilts, a reporter with the *San Francisco Chronicle* since 1982, is the only journalist to have worked full-time on the story of AIDS, the Acquired Immune Deficiency Syndrome, as it unfolded. This thought-provoking monograph has chronicled, month by month, the story behind AIDS. It is an evocative recent account of disease and society.

And the Bank Played On documents the events of the AIDS epidemic from before 1980 (as told in Parts I and II) until 1987 (Part IX). These events are interwoven around five developments: the research which resulted in the isolation of the pathogen, Human Immunodeficiency Virus, HIV, and its link to AIDS; the public health/private rights debate (or lack of it) as to what action was needed to prevent AIDS being sexually transmitted (p.498, for example); the disinterest of, and opposition from, commercial enterprises, *viz.* the blood banks and the Gay bathhouses, regarding the parts they were playing in the spread of the disease (p. 374 *ff.*, for example); the neglect of the press to consider the epidemic a legitimate news story that was worthy of thorough coverage; the efforts of the few who were far-sighted enough to realise the seriousness of AIDS and who put their careers on the line in order to take action (pp. 357-8, 368-9).

Undergirding these developments, the fundamental issue is presented, through anecdote after anecdote, that the little funding which was allocated to research and information about AIDS in the United States, was always coming inexcusably slowly. But every so often in the accounts, Shilts walks his reader into the lives of those dying from AIDS, lest we forget the greatness of the physical and mental suffering of the victims, and the herosim of so many of them. The story of Gary Walsh stands out (pp. 423-8). Since it is not possible to address all these stories here, I have selected three particularly pertinent ones.