Exorcising Laplace's Demon: Chaos and Antichaos, History and Metahistory

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EXORCISING LAPLACE'S DEMON: 
CHAOS AND ANTICHAOS, HISTORY AND METAHISTORY

MICHAEL SHERMER

ABSTRACT

The analysis of physical and biological systems through models and mathematics of chaotic behavior and nonlinear dynamics rose to prominence in the 1980s. Many authors, most notably Ilya Prigogine and Isabelle Stengers, made glancing references to applications of this new paradigm to the social and historical sciences, but little fruit was harvested until this decade. Physiologists studying irregular heart rhythms, psychologists examining brain activity, biologists graphing population trends, economists tracking stock price movements, military strategists assessing the outbreak of wars, and sociologists modeling the rise of cities, found nonlinear dynamics refreshingly stimulating in reevaluating (and often restructuring) old theories and creating new ones. Modeling the past was an inevitable extension of this trend, and theorizing on the new historiography soon followed, with the terms of the debate outlined from 1990 to 1993 by Alan Beyerchen, Katherine Hayles, Stephen Kellert, Charles Dyke, myself, and, in the pages of History and Theory, by George Reisch and Donald McCloskey. The subject of “the chaos of history” is now enjoying a healthy exchange of ideas from all sides. This essay: (I) reviews the precedents for integrating chaos and history; (II) gives a brief history of this integration including an evaluation of a critique of Reisch and McCloskey by Roth and Ryckman, and presents a metahistory of how chaos theory explains its own development; (III) defends a chaotic model of historical sequences; (IV) gives a specific historical example of nonlinear history; (V) explores the latest trends in the field of self-organization, antichaos, simplexity, and feedback mechanisms, providing data to show that modern and historical social movements change in a parallel fashion; and (VI) exorcises Laplace’s demon by showing it was always a chimera.

I. HUMAN BEHAVIOR WRIT PAST

Historians do not commonly turn to engineers for insight into how and why the past unfolds as it does. But since the process of modeling history in the language of chaos theory and nonlinear dynamics is a rapidly burgeoning and

1. I recognize the distinction between chaos theory and nonlinear dynamics, and that many scientists in the field do not think chaos is a theory or a science, but more of a tool or model for dealing with certain phenomena. I realize also that while some find the term “chaos” a useful one, others shy away from it because it has become popularized and lost its precision as a description of certain nonlinear actions. Stephen H. Kellert (In the Wake of Chaos [Chicago, 1993], 28), for example, concludes a long discussion of this problem as such: “Chaos proves to be a useful term indeed in a wide variety of scientific investigations.” Although N. Katherine Hayles (Chaos and Order: Complex Dynamics in Literature and Science [Chicago, 1991], 2) claims “the word [chaos]
richly interdisciplinary sphere of study far afield from traditional historiography, it may be fruitful to seek the thoughts of one whose vision has been sharper than most. Paul MacCready, inventor of human- and solar-powered flight, pioneer of electric automobiles, and engineer extraordinaire, upon reading my paper on chaos and history,² found himself “thinking of a note I contributed to American Scientist wherein some 75 scientists described what got them into science. I was the only respondent to note that a person answering this question creates a plausible history, but not necessarily a real one.”³ MacCready recalled: “There were innumerable influences in your past, but you remember only a few of the major ones, and you instinctively weave these into a plausible history explaining how you became what you presume you are. This interpretation of history is both logical and nonfalsifiable and so tends to establish its own validity. Chances are it’s wrong.”⁴

This problem of reconstructing the past to explain the present is, of course, an old and familiar one to philosophers of history but in this context needs restating because there is considerable risk in weaving plausible histories with instruments from another science. Are we, as William H. McNeill recalled he once did, merely remodeling history to fit the language of a new physics?: “I find your argument about chaos and history entirely congenial, though when I was young and struggled with finding my own ways of thinking about these questions I was drawn to the language of an older physics, seeing human society as a species of equilibrium, nested within other equilibria—biological, physical—and each level of equilibrium interacting with the others.”⁵ Is this no more than an epistemological game of chasing the latest trends in the physical sciences? If history changes with the physics of the day, then are we no closer to understanding what really happened and why? Perhaps, but then all of the sciences could be accused of the same limitation. Science is not the affirmation of a set of beliefs but a process of inquiry aimed at building a testable body of knowledge open to rejection or confirmation. So too is history (or at least

has now become so thoroughly deprofessionalized that its use is regarded as a signal that one is in the presence of a dilettante rather than an expert,” she also decided that “it will be retained in this volume precisely because of the ambiguous meanings that inhere within it.” Likewise, I will use the terms “chaos theory” and “nonlinear dynamics” interchangeably with the understanding that scientists may alter the meanings and usages in the future. I shall also define it within the context of the model of contingent-necessity later in the paper.


5. Personal correspondence, May 22, 1993. McNeill offered this additional caution: “I think the new burst of chaos theory has a lot to teach historians and am glad to find you doing it. In general we are an untheoretical profession: learn by apprenticeship and reflect little on the larger epistemological context of our inherited terms. But clarity is always desirable and you seem bent in that direction. I wish you well in illuminating the historical profession; but suspect most of my colleagues will not even try to understand!”
it should be). Thus, making such applications from another field is no more and no less than what others have always done.

The integration of chaos and history uses a theory of present change to explain past change. Niles Eldredge and Stephen Jay Gould make it quite clear that this is precisely what they were doing in the development of their evolutionary theory of punctuated equilibrium, in applying the modern theory of allopatric speciation to the paleontological record. Lewis Binford's "new archaeology" is an attempt at just such an integration from the present to the past. He claims the job of the archaeologist is not just to record the raw data of a dig but to interpret human action from human artifacts by the development of "principles determining the nature of archaeological remains to propositions regarding processes and events of the past." This is what Fernand Braudel insists be done in the application of psychological, sociological, and economic theories to history. Human history is human behavior writ past.

II. CHAOS, HISTORY, AND METAHISTORY

When did chaos theory arise and how did it get applied to the social sciences and history? Single-point origin myths are the mainstay of potted histories, compelling because of their simplicity and the ease of acknowledging the creating hero. Unfortunately they are rarely true. History is contiguous, so arguments for creative discontinuity only work when one does not look too closely at the historical record. Christopher Sholes did not invent the typewriter for Remington in the 1860s; there were at least 112 other writing machines dating back to the first patent in 1714. Abner Doubleday did not invent baseball in 1839; it evolved from English stick-and-ball games of the early 1700s. Likewise for both chaos theory and its applications to the social sciences and history. No one person gets the credit, and both movements have a culture-bound history.

Ironically, the theory itself may explain how and why its own history and applications developed as they did.

Chaos theory and nonlinear dynamics have their roots in late nineteenth-century physics, but it was three-quarters of a century before scientists began to see such unusual phenomena as anything but noise in an otherwise predictable

7. Lewis Binford, An Archaeological Perspective (New York, 1972), 96; In Pursuit of the Past: Decoding the Archaeological Record (London, 1983); Working at Archaeology (New York, 1983). What Binford attempts is admirable, and though he has been recently attacked by Paul Courbin in What is Archaeology? (Chicago, 1988) for falling to live up to his own standards, inadequate application does not negate the principle. Where Binford does go wrong, and Courbin calls him on this, is his attempt to construct social laws, such as the size of a Bushman site being directly proportional to the number of houses in it. The problem with such laws is that they either state the obvious, or, as Courbin explains, "The 'law and order' archaeologists . . . have striven to impose their order far more than they have actually succeeded in elaborating the laws which they declared at the start to be utterly indispensable" (60). Apparently the quest for covering laws in archaeology has also failed.
and classically determined universe. Stephen Kellert has explored the "nontreatment of chaos" throughout the first half of the twentieth century; among the many factors that led scientists to ignore chaos (for example, inadequate computers), he shows that physicists had not yet learned to look for chaos. What they did not look for they did not find. Chaotic phenomena and nonlinear activity were literally and figuratively seen as anomalous data, natural noise, and experimental error to be dismissed. The focus of physics was the small-scale quantum and the large-scale cosmological, with a special emphasis on the linear nature of these systems. Through an analysis of textbooks on dynamics throughout the twentieth century, Kellert shows that it was not until the 1960s that nonlinearity began to be treated as something worth further exploration. Overwhelmingly, he says, it was the "metaphysical comforts of determinism" that explains "why apparently random or 'noisy' experimental results might be so easily dismissed as unsuitable for scientific investigation." Why, then, did chaos theory take off when it did? According to Kellert, both scientific and "extrascientific parts of society" made it ripe for acceptance. Of the former, prediction and control of nature as a goal of science is aided by chaos theory because it "yields qualitative predictions for systems where detailed quantitative predictions are impossible." Of the latter, Kellert appeals to a feminist interpretation of science. He argues that the "mechanistic view of the world served as a legitimating ideology for the project of dominating nature," an ideology that traditionally excluded women because they were "linked to the wild, disorderly features of the natural world perceived as needing to be subdued." Chaos theory was legitimized in the late 1970s and early 1980s when women were allowed to join the club. When science, technology, and culture became ready for chaos, meaningless noise became meaningful data.

In a similar interpretation, Katherine Hayles sees a simultaneous development of chaos theory and postmodern culture, including literary deconstructionism. To go from the nineteenth-century determinism of the second law of thermodynamics to modern chaos theory, Hayles takes us on a journey that begins with Henry Adams's observation in 1907 that "Chaos was the law of Nature; Order was the dream of man," and includes quantum physics, relativity theory, information theory, postmodernism, and the indeterminism of deconstructive literary theory. The conjunction of these ideas and movements readied the scientific community to accept chaos as a part of nature worthy of study. Whether Kellert and Hayles got it right remains to be seen until greater distance unfolds between event and historian, and the overall impact of these cultural movements becomes more clear.

In a similar vein we may also ask how it is that so many individuals from such different fields independently and nearly simultaneously made the connections between chaos and the social sciences? Why, in short, did Clio meet Chaos in

the late 1980s and early 1990s and not sooner or later? The answer tells us something about the nature of historical change and is itself a metahistory. In chaos theory a \textit{strange attractor} causes the flow of change in a dynamic system to be "attracted" to certain points in the system. A swinging pendulum placed over a couple of strong magnets will be influenced by them in such a way as to cause its swing to be best described by nonlinear mathematics. The magnets are attractors. Similarly, historical focal points in a chronological system act like chaotic strange attractors in a dynamical system. That is, there are special points in history when there is a particular conjunction of events that creates conditions ripe for significant change, as we saw with the development and acceptance of chaos theory itself. These historical focal points act like a strange attractor, drawn to a particular problem through a parallel development of contingencies. A series of contingencies constructs necessities to produce a limited range of future possibilities. The more similar the contingent series, the more likely the distant necessities will resemble each other (though they will never be exactly the same because of the sensitive dependence on initial conditions).

It was not long after nonlinear dynamics gained legitimacy in the late 1970s and early 1980s that sometimes cautious, sometimes bold forays were made into applications of chaos theory to human history. In 1984, Ilya Prigogine's and Isabelle Stengers's widely-read popular treatment \textit{Order Out of Chaos} made a few direct comparisons from physics and chemistry to human history, though they were mostly of a speculative nature, such as this conclusion to the book: "We know now that societies are immensely complex systems involving a potentially enormous number of bifurcations exemplified by the variety of cultures that have evolved in the relatively short span of human history."\textsuperscript{11} Military applications were made in 1984 when Alvin Saperstein suggested that "war be viewed as a breakdown in predictability; a situation in which small perturbations of initial conditions, such as malfunctions of early warning radar systems or irrational acts of individuals disobeying orders, lead to large unforeseen changes in the solutions to the dynamical equations of the model."\textsuperscript{12} Riane Eisler and David Loye published a paper on "Chaos and Transformation" in 1987, speculating on the implications of nonequilibrium theory for history, society, and the social sciences, offering broad and sweeping generalizations, especially for the future.\textsuperscript{13} In 1988 I presented a paper on "The Historical Matrix Model: A Theory of Historical Contingency" at the \textit{Interface} conference in Atlanta, mostly focusing on the sensitive dependence of initial historical conditions without any direct reference to chaos theory or nonlinear dynamics. In 1989 economic applications of chaos and complexity were made in essays by W. A. Brock and

\textsuperscript{11} Ilya Prigogine and Isabelle Stengers, \textit{Order Out of Chaos} (New York, 1984), 313.
\textsuperscript{12} Alvin Saperstein, "Chaos: A Model for the Outbreak of War," \textit{Nature} 309 (May 24, 1984), 303–305.
by W. Baumol and J. Benhabib, exploring chaos as a mechanism of economic change. In 1990 Alan Beyerchen called nonlinear science “a new intellectual vision,” comparing it with the scientific revolution of the sixteenth and seventeenth centuries and the corresponding changes in worldview; and in 1992, he made a direct comparison between Clausewitz’s theory of war and nonlinear models of military historical change. Katherine Hayles’s 1991 edited collection on Chaos and Order presented an array of applications and limitations of integrating nonlinear dynamics into the human sphere. “Although it is too soon to say where the discoveries associated with complex systems will end,” Hayles boldly speculated, “it is already apparent that chaos theory is part of a paradigm shift of remarkable scope and significance.”

In 1990, Charles Dyke published “Strange Attraction, Curious Liaison: Clio Meets Chaos,” the first serious work to appear on the historical applications of chaos, in which he was quite cautious about “the unbounded enthusiasm associated with this new and very seductive mathematics.” At times Dyke seemed openly sarcastic in his criticisms of those excited about the possibilities who “run off to their computers to try and locate strange attractors in the stock market, reconstruct neoplatonic mysticism fractally, and the like. I hate to be a killjoy . . . .” Perhaps anticipating the conservative reaction such cross-disciplinary integration usually receives in the scholarly community, Dyke then cautiously ventured forth some possibilities. The ceteris paribus assumption of all other things being equal, Dyke concluded, cannot hold true in any system that is sensitive to initial conditions. Economic theory is an obvious choice for an example of what Dyke calls “the crossed fingers of positivist explanation,” because all other things are never equal. “Simple linearities would be surprising in anything as complex as a person or a social system.” One of the most important points Dyke made is in a brief discussion of the nineteenth-century fascination with the “great men” of history. What made them great? Divine providence? Special ability? Dismissing the former as untenable for a secular interpretation and the latter as refutable by the fact that lots of talented people never became “great,” Dyke turned to a “special circumstances” interpretation in which “historically, under some conditions of stability even very able people

19. Ibid., 380.
won't be expected to have much of an impact on what goes on. But under conditions of extreme instability—the late Roman Republic, France after a few years of revolutionary government and war, for example—someone with a threshold level of ability in the right place at the right time can have an enormous impact."

In its February 1991 issue *History and Theory* published two essays as a Forum on "Chaos Theory and History": one by George Reisch entitled "Chaos, History, and Narrative," the other by Donald McCloskey called "History, Differential Equations, and the Problem of Narration." In his essay Reisch pointed out that virtually everyone believes that "the real vehicle of historical knowledge . . . is narration," while "covering-law history has been rejected." But he also noted that "The fact that . . . [no laws] have been produced does not prove that there will never be any. . . . it has not been shown to have defects which render it essentially unable to fulfill the goals Hempel designed it to meet." Despite this disclaimer Reisch claimed his goal was to demonstrate that since history is chaotic, "it is characteristic of events in chaotic systems that they just cannot be explained with covering laws and initial conditions," and thus "this argument against covering-law history is simultaneously one in favor of narrative." 

After demonstrating that history is chaotic, Reisch observed that the problem with covering-law history is "the greater the temporal distance between initial (and intervening) conditions on the one hand and the event to be explained on the other, the greater the accuracy with which those conditions must be known." The greater the temporal distance, however, the less accuracy we have, and thus the more difficult it is to find covering laws. Even Hempel confessed that "the complete description of an individual event . . . can never be completely accomplished." Thus, Reisch concludes, "this is precisely why covering-law history is not viable." Earlier in his paper, however, and strangely buried in a footnote, Reisch admits that "My argument grants that historical laws might be available which, like scientific laws, specify precisely which descriptions of events need be constructed, descriptions which need not be couched in future-referring sentences. . . ." Two pages later he says that "the only way it [covering-law history] can remain standing is to divide the time over which its laws purportedly act into many small consecutive intervals or scenes." These scenes, of course, are narrative in structure, and thus his defense of narrative history

20. Ibid., 382-383.
23. Ibid., 17.
26. Ibid., 16.
27. Ibid., 18.
stands. As we shall see, my model does precisely what Reisch requires by dividing time into small consecutive intervals. Whether these intervals are presented in narrative or analytic form is irrelevant.

Donald McCloskey's launching point for nonlinear historical modeling is everyone's favorite military metaphor: for the want of a horseshoe nail the kingdom was lost. It is this sensitive dependence on initial conditions and the role of contingencies in history on which McCloskey primarily focused, as he systematically dismantled the "Dogma of Large-Large." McCloskey discussed the attractiveness of chaos to those who still look for human volition in history, because "chaos... can lead to activism. The president hoping that his jawboning will end a depression is a nonlinear dynamist." McCloskey, however, failed to resolve the paradox between history being "governed by big simple, linear metaphors" and "models of nonlinear feedback" in which "the story becomes unmanageable, untellable." In the end, says McCloskey rather grimly, "The fossils do not tell a story about the Cambrian explosion: we tell it. For the human sciences the case is worse." As I hope to show, however, the story can be quite manageable and even tellable in a narrative, when the sequences are divided, defined, and (where appropriate) modeled nonlinearly. Further, the fossils do tell us a story, and we can even discover the true story when the history is narrated by scientists who present evidence for their case. Other historians may prove them wrong, of course, but the key word is prove. Not all histories are equal. (To show the absurdity of extreme historical relativism one has only to inquire if equal weight should be placed on the Holocaust revisionists' claim that the Holocaust never happened.)

A strong critique of the attempt to apply chaos to history has now been formulated by Paul Roth and Thomas Ryckman who, along with Reisch and myself, participated in an American Historical Association conference session in January, 1994. The session was scheduled on the afternoon of the final day of the conference when attendance is traditionally low, and we were located in a small converted guest room on a top floor nowhere near the main conference. Despite this the room was packed with over sixty attendees who created an extremely lively discussion focusing on basic issues dealt with by chaos theorists long before (for example, implications for traditional determinism, human free will, causality). One non-historian member of the audience, Steve Farmer, was almost indignant that historians were still mired in the muck of such philosophical ponderings while others (himself included) were already constructing nonlinear histories from a variety of periods and fields, soon to be published to the chagrin of the historical community left out of the action.

29. Ibid., 34.
30. Ibid., 36.
31. Paul A. Roth and Thomas A. Ryckman, "If Historical Explanation is the Problem, Can Chaos Theory Be the Answer?"; George Reisch, "Chaos, History, and Narrative"; Michael Shermer (Session Chair), "On a Chaotic Model that Represents the Role of Contingency and Necessity in Historical Sequences," AHA Annual Conference (January 9, 1994).
"You guys are going to be embarrassed when these works are published," he boasted. "The proof is in the pudding," Ryckman responded. "We will wait to see what you've got."32

Farmer and his cohorts have yet to produce but his first point is well taken. While we continue debating whether the past exhibits nonlinear properties and ask if history is chaotic, physicists, biologists, mathematicians, computer scientists, and economists have moved beyond chaos to antichaos, complexity, simplicity, complexification, simplicity, complicity, the collapse of chaos, and even the rise of post-chaos and post-complexity. Part of the problem is that the body of literature on chaos theory and nonlinear dynamics is growing so rapidly that it is virtually impossible to keep up with it, especially for historians busy with their own research. Most of it is highly mathematical so that without adequate grounding in the language one is quickly lost. Books and articles exploring the nonlinear dynamics of social, political, economic, and historical systems, however, are highly readable and are coming off the presses regularly. In addition, organizations such as the Santa Fe Institute (SFI) are being formed to further promote such cross-disciplinary scholarship. Roger Lewin's Complexity: Science on the Edge of Chaos and Mitchell Waldrop's Complexity: The Emerging Science at the Edge of Order and Chaos trace the history of the SFI where physicists, mathematicians, computer scientists, biologists, and economists (such as Nobel Laureates Murray Gell-Mann and Kenneth Arrow) construct models to show how complex systems spontaneously generate out of simple ones, how the reverse is also true, and how chaos and order interact to both create and destroy—from the origins of galaxies and life to the collapse of the stock market and the Soviet Union.33 For example, Stuart Kauffman's The Origins of Order shows that complex living systems such as species and human societies arise by their own laws of assembly and interaction (for example, morphological similarities among organisms and their adaptations to their environments sometimes occur independently of Darwinian natural selection).34 SFI Fellow John Casti, in Complexification, explores several types of physical phenomena and their correspondence in the social/historical realm, including: catastrophic (earthquakes and political revolutions); chaotic (the weather and the stock market); paradoxical (adding more lanes to a freeway increases congestion); irreducible (books and symphonies are more than the sum of their parts); and emergent (life, cities, and civilizations).35 Economist Brian Arthur regards the economy as a complex adaptive system driven by negative feedback mechanisms (supply and demand fluctuations keep an economic system in balance) and positive feedback mechanisms (marketing and

32. Ibid., tape recording of question and answer period.
advertising help one firm get a jump on others, which gives it more capital to increase its marketing and advertising, and so on).\textsuperscript{36} Jack Cohen and Ian Stewart, a reproductive biologist and mathematician respectively, have just released \textit{The Collapse of Chaos}, moving beyond chaos theory and twisting complexity both physically and linguistically into a theory of \textit{complicity} and \textit{simplicity}, where an interaction of chaos and complexity leads to simplicity.\textsuperscript{37}

What is missing from this picture? Historians. According to John Casti, no historians have ever worked at the SF1.\textsuperscript{38} No historian has produced a major work on chaos and history. George Reisch remains optimistic, arguing in his paper in this issue of \textit{History and Theory}, that “accurate dynamical models of history, were we able to produce them, would be nonlinear” (58). Paul Roth and Thomas Ryckman on the other hand “remain decidedly skeptical that any truly beneficial assistance to metahistorical studies will be rendered by overblown comparisons with the dynamics of nonlinear systems” (44, in this issue).

Echoing his previous commitment to exploring the possibilities of nonlinear history, Reisch continues to maintain that historical covering laws cannot be composed into large-scale covering-law explanations, as Hempel had hoped. The reason is the sensitive dependence on initial conditions where “any error in the specification of the initial state, \(A\), will grow exponentially in (simulated) time.” The solution, Reisch concludes (correctly, I hope to prove), is to divide the simulation into shorter segments so that “an accurate explanation of \(E\) can still be constructed” (48).

From the beginning Roth and Ryckman set the reader up for either-or choices about chaos and history. Either nonlinear dynamics “is held to be literally driving historical processes” or “it provides only a suggestive analogy or perhaps metaphor for fashioning a new genre of historical narrative” (31). Therefore, one must choose between two theses: the Causal Thesis, which “holds that chaos theory can be used to plausibly model, and so explain, causal relations for at least some historical events” (32); or the Convergence Thesis, which “states that, once the analogy between history and chaos theory is properly appreciated, any temptation to divide history from (the rest of?) science should be greatly lessened” (32–33). Roth and Ryckman then work mightily to undermine the Causal Thesis in Reisch’s analysis, primarily focusing on only one component of chaos theory—the sensitive dependence on initial conditions. Because Reisch admits that this part of chaos prohibits Hempelian covering laws, Roth and Ryckman conclude that “as goes the Causal Thesis so goes Convergence.” Thus, those of us using the “terms and concepts” of chaos are doing nothing more than promoting “pseudoscientific ‘accounts’ of the character of history” (44).


\textsuperscript{38} Casti, personal correspondence (July 1, 1994).
Cutting through Roth's and Ryckman's philosophical contortions and logical enumerations to the heart of their argument, essentially what they say is, "that's interesting—PROVE IT." Fair enough. God and historians dwell in the details. Metaphorical formulas, logical syllogisms, and theoretical models are fine for starters, but where can we find chaos in the past? Reisch claims that "we do not have fully specified models of particular historical processes" (53). Roth and Ryckman demand real examples of historical nonlinearity. What I will do is provide both in the next two sections, followed by historical examples that move far beyond Reisch's, Roth's, and Ryckman's preliminary explorations—into the realm of antichaos, complexity, self-organized criticality, and feedback mechanisms.

III. A CHAOTIC MODEL OF HISTORICAL SEQUENCES

The issue of randomness and predictability in physical, biological, or social systems remains one of the great issues of our time in part because it touches on such deeply meaningful questions as free will and determinism. Carl Hempel lives because he looked for predictability through historical covering laws, and concluded that "There is no difference between history and the natural sciences." Hempel was wrong about covering laws, but right about history and the natural sciences; not, however, in the direction one might think. History is not governed by Hempel's "universal conditional forms," but neither are the physical and biological worlds to the extent we have been led to believe. Scientists are coming to realize that the Newtonian clockwork universe is filled with contingencies, catastrophes, and chaos, making precise predictions of all but the simplest physical systems virtually impossible. We could predict precisely when Comet Shoemaker-Levy 9 would hit Jupiter last July, but could muster at best only a wild guess as to the effects of the impacts on the Jovian world. The guess was completely wrong. Why? The answer strikes at the heart of understanding the nature of causality, as Stephen Jay Gould notes: "Do large effects arise as simple extensions of small changes produced by the ordinary, deterministic causes that we can study every day, or do occasional catastrophes introduce strong elements of capriciousness and unpredictability to the pathways of planetary history?"

There is irony in Gould's inquiry. For decades historians chased scientists in quest of universal laws, but gave up and returned to narratives filled with capricious, contingent, and unpredictable elements that make up the past, resigning themselves to the fact that they would never be as good as scientists. Meanwhile, a handful of scientists, instead of chasing the elusive universal form, began to write the equivalent of scientific narratives of systems' histories, integrating historical contingencies with nature's necessities. Ironically, says Gould, "This essential tension between the influence of individuals and the

power of predictable forces has been well appreciated by historians, but remains foreign to the thoughts and procedures of most scientists.\textsuperscript{41} Gould demonstrates how even a subject as predictable and subservient to natural law as planets and their moons; when examined closely, reveals so much uniqueness and individuality that while "We anticipated greater regularity . . . the surfaces of planets and moons cannot be predicted from a few general rules. To understand planetary surfaces, we must learn the particular history of each body as an individual object—the story of its collisions and catastrophes, more than its steady accumulations; in other words, its unpredictable single jolts more than its daily operations under nature's laws."\textsuperscript{42} History matters. Narrative lives.

Historians, in fact, have been cognizant for millennia of the basic principles of chaos and nonlinearity. The principles, though, are coded in a different language and grouped into two fundamental "forces" that guide historical sequences—contingency and necessity. In this analysis "contingency" will be taken to mean \textit{a conjuncture of events occurring without perceptible design}, and "necessity" to be \textit{constraining circumstances compelling a certain course of action}. Contingencies are the sometimes small, apparently insignificant, and usually unexpected events of life—the kingdom hangs in the balance awaiting the horseshoe nail. Necessities are the large and powerful laws of nature and forces of history—once the kingdom has collapsed 100,000 horseshoe nails will not help a bit. Leaving either contingency or necessity out of the historical formula, however, is to ignore an important component in the development of historical sequences. The past is composed of both: therefore it is useful to combine the two into one term that expresses this interrelationship—"contingent–necessity"—taken to mean \textit{a conjuncture of events compelling a certain course of action by constraining prior conditions}.

Randomness and predictability—contingency and necessity—long seen to be opposites on a quantitative continuum, are not mutually exclusive models of nature between which we must choose. Rather, they are qualitative characteristics that vary in the amount of their respective influence and at what time their influence is greatest in the chronological sequence. No one denies that such historical necessities as economic systems, demographic trends, geographical locales, scientific paradigms, and ideological world-views exert a governing force upon individuals falling within their purview. Contingencies, however, exercise power sometimes in spite of the necessities influencing them. At the same time they reshape new and future necessities. There is here a rich matrix of interactions between early pervasive contingencies and later local necessities, varying over time, in what I shall call the \textit{model of contingent-necessity} which states that \textit{in the development of any historical sequence the role of contingencies in the construction of necessities is accentuated in the early stages and attenuated in the later.}

\textsuperscript{42} Ibid., 24.
The following are five corollaries that encompass different aspects of the model:

**Corollary 1:** The earlier in the development of any historical sequence the more chaotic are the actions of the individual elements of that sequence and the less predictable are future actions and necessities.

**Corollary 2:** The later in the development of any historical sequence the more ordered are the actions of the individual elements of that sequence and the more predictable are future actions and necessities.

**Corollary 3:** The actions of the individual elements of any historical sequence are generally postdictable but not specifically predictable, as regulated by Corollaries 1 and 2.

**Corollary 4:** Change in historical sequences from chaotic to ordered is common, gradual, followed by relative stasis, and tends to occur at points where poorly-established necessities give way to dominant ones so that a contingency will have little effect in altering the direction of the sequence.

**Corollary 5:** Change in historical sequences from ordered to chaotic is rare, sudden, followed by relative nonstasis, and tends to occur at points where previously well-established necessities have been challenged by others so that a contingency may push the sequence in one direction or the other.

At the beginning of any historical sequence, actions of the individual elements are chaotic, unpredictable, and have a powerful influence on the future development of that sequence. As the sequence gradually develops and the pathways slowly become more worn, out of chaos comes order. The individual elements sort themselves into their allotted positions, as dictated solely by what came before—the unique and characteristic sum and substance of history, driven forward on the entropic arrow of time by the interplay of contingency and necessity.

As a *historical sequence*, the model of contingent-necessity is limited in its analysis to a specified range of chronological margins that is chosen by the historian. In other words, a historical sequence is what the historian says it is. The variables, however, are not arbitrarily chosen. The historian can present evidence for the significance of these precise starting and stopping points, which is what we already do. Once these chronological boundaries are established, then the model of contingent-necessity and its corollaries can be used as a heuristic framework for representing what happened between these limits. A *historical sequence is a timeframe determined by the focal point and the boundaries of the subject under investigation.*

Contingent-necessity and chaos are not dissimilar. At the 1986 Royal Society of London conference on chaos Ian Stewart reported that scientists devised this seemingly paradoxical definition of chaos: “Stochastic behaviour occurring in a deterministic system.” Stewart noted that since “stochastic behaviour is . . . lawless and irregular,” and “deterministic behaviour is rule by exact and unbreakable law,” then “chaos is 'lawless behaviour governed entirely by law,'”
an obvious contradiction.\textsuperscript{43} When chaos scientists use the word, however, they do not mean lawless and random behavior; they mean \textit{apparent} lawless, random behavior. The order is hidden from view by traditional methods of looking (such as linear mathematics). The apparently chaotic actions of the phenomena exhibit an interaction between the small, contingent events of a sequence and the large, necessitating laws of nature. When looked at in the light of contingent-necessity, it becomes possible to define chaos in the following way: \textit{Chaos is a conjuncture of events compelled to a certain course of action by constraining prior conditions.} Chaos and contingent-necessity model phenomena in the same manner, as Ilya Prigogine notes when observing that in chaos the "mixture of necessity and chance constitutes the history of the system."\textsuperscript{44} In like manner, necessity and contingency are the shaping forces for historical sequences. If this correspondence between chaos and contingent-necessity exists, then we can draw certain analogies between physical and biological chaotic phenomena and human historical ones.

According to Prigogine, all systems including historical ones contain subsystems that are "fluctuating." As long as the fluctuations remain modest and constant, relative stasis in the system is the norm. If the fluctuation becomes so powerful that it upsets the preexisting organization and balance, a major change or revolution may occur, at which point the system may become chaotic. This point of sudden change is called the bifurcation point. Necessity takes a system down a certain path until it reaches a bifurcation point. At this time contingency plays an exaggerated role in nudging the system down a new path, which in time develops its own powerful necessities such that contingency is attenuated until the next bifurcation. The alloy of contingency and necessity guides and controls the presence or absence of these bifurcations, as Prigogine notes in similar language: "The 'historical' path along which the system evolves as the control parameter grows is characterized by a succession of stable regions, where deterministic laws dominate, and of instable ones, near the bifurcation points, where the system can 'choose' between or among more than one possible future."\textsuperscript{45}

In the language of contingent-necessity, a bifurcation or "trigger of change" is \textit{any stimulus that causes a shift from the dominance of necessity and order to the dominance of contingency and chaos in a historical sequence.} Examples in history abound: inventions, discoveries, ideas, paradigm shifts, scientific revolutions, economic and political revolutions, war, famine and disease, invasions, immigrations and emigrations, population explosions, natural disasters, climate and the weather, and so on, all have the potential for triggering a sequence to change from order to chaos. A trigger of change, however, will not cause a shift at just any point in the sequence. Corollary 5 states that a trigger of change will be most effective when well-established necessities have been challenged by others so that a contingency may push the sequence in one

\textsuperscript{43} Stewart, \textit{Does God Play Dice?}, 17.
\textsuperscript{44} Prigogine and Stengers, 169.
\textsuperscript{45} \textit{Ibid.}, 169-170.
direction or the other. This bifurcation point or "trigger point" is *any point in a historical sequence where previously well-established necessities have been challenged by others so that a trigger of change (contingency) may push the sequence in one direction or the other.*

In like manner the sensitive dependence on initial conditions—the butterfly effect—has direct application to Corollaries 1 and 2 dealing with the point of time in the sequence—early or late—and the chaotic or ordered nature of that sequence. The butterfly effect or the "trigger effect" is *the cascading consequences of a contingent trigger of change in a historical sequence.* The trigger effect is linked with Corollary 1 in which the earlier in the development of any historical sequence, the more chaotic are the actions of the individual elements of that sequence and the less predictable are future actions and necessities; as well as Corollary 2, which reverses the influence of the trigger effect because the later in the development of any historical sequence the more ordered are the actions of the individual elements of that sequence and the more predictable are future actions and necessities. Therefore the power of the trigger depends on *when* in the chronological sequence it enters. As stated in Corollary 5, change tends to occur at points where previously well-established necessities have been challenged by others so that a contingency may push the sequence in one direction or the other. The flap of the butterfly's wings in Brazil may indeed set off a tornado in Texas, but only when the system has started anew or is precariously hanging in the balance. Once the storm is well under way, the flap of a billion butterfly wings would not alter the outcome for the tornado-leery Texans. The potency of the sequence grows over time. In human history the trigger effect is quickly erased once the patterns begin to settle in. An individual of great talent may have little effect in regions of stability, while another of modest competence might deflect the entire sequence in regions of instability. The "great men" of history, as Dyke correctly inferred, found themselves at trigger points where well-established necessities had been challenged by others so that their contingent push jolted the sequence down a new path with the corresponding cascading consequences.

The corollaries do precisely what George Reisch requires for laws, that they "divide the time over which its laws purportedly act into many small consecutive intervals or scenes. That is, covering-law explanations must be resolved into narrative temporal structures." Historical sequences make up these consecutive (and contiguous) intervals over which the model of contingent-necessity operates. Corollaries 1 and 2 describe the chaotic or ordered nature of an interval depending on the temporal sequence within them; Corollaries 4 and 5 describe when and why intervals shift from chaotic to ordered and vice versa. Whether these sequences are presented in narrative or analytic form does not change the actions of the historical elements.

Historical examples of chaos and contingent-necessity abound. One in particular is especially illustrative of the model and its corollaries. Regular users of typewriters and computers are historically locked into the standard QWERTY keyboard system, denoting the first six letters from the left on the top letter row. Personal computer and typewriter keyboards still use the antiquated QWERTY system designed for nineteenth-century typewriters whose key striking mechanisms were too slow for human finger speed. Even though more than seventy percent of English words can be produced with the letters DHIATENSOR, a quick glance at the keyboard will show that most of these letters are not in a strong striking position (home row struck by the strong first two fingers of each hand). Six of the ten letters are not on the home row (ITENOR are above and below) and one letter (A) is struck by the weak left little finger. All the vowels in QWERTY, in fact, are removed from the strongest striking positions, leaving only thirty-two percent of the typing on the home row. Only about 100 words can be typed exclusively on the home row, while the weaker left hand is required to type over 3,000 different words without using the right hand at all. (It might also be noted that the word “typewriter” can be typed with letters all found on the top row. Apparently this was arranged so that typewriter salesmen could show off their new technology to prospective buyers with this clever trick.)

This keyboard arrangement originally came about for numerous reasons and by a number of contingent causes; once set in motion (and given enough time), this conjunction of events necessitated our inheritance of the system. With a check of the home row on the keyboard one can see the alphabetic sequence (minus the vowels) DFGHJKL. It would seem that the original key arrangement was just a straight alphabetical sequence, which made sense in early experiments before testing was done to determine a faster alignment. But why remove the vowels? In Christopher Latham Sholes’s original 1860s model, the QWERTY keyboard was designed to prevent key jamming because the paper was struck by the keys from underneath, and one could not see the page until it was nearly complete. Such an arrangement made it possible not only to type numerous unseen mistakes, but to jam the keys altogether and to type a continuous line of one letter. The most-used letters were removed from strong striking positions to slow the typist down. This problem was eventually remedied by using a

front-facing roller with the paper scrolled around it so the typist could see each letter as it was struck. By then, however, QWERTY was so entrenched in the system (through manuals, teaching techniques, and other social necessities) that it became virtually impossible to change. Once entrenched the QWERTY keyboard became inevitable in American business and culture.

In 1882, the Shorthand and Typewriter Institute in Cincinnati was founded by one Ms. Longley, who chose to adopt, among the many competing keyboard arrangements, the QWERTY system. As the school became well-known her teaching methods became the industry standard, even adopted by Remington, which also began to set up typing schools using QWERTY. In 1888 a contest was arranged between Longley's method and that of her competitor Louis Taub, who used a different typing technique on a non-QWERTY keyboard. Longley's star pupil, Frank McGurrin, apparently thrashed the competition by memorizing the entire QWERTY keyboard and typing by touch alone—an innovative technique for the time. The event generated much publicity and touch-typing became the method of choice for American typists. The Sholes-designed and Remington-manufactured typewriter with the QWERTY keyboard became necessary to the point that it would take a typing revolution to reshuffle the keyboard deck. Unless the major typewriter and computer companies, along with typing schools, teachers and publishers of typewriter manuals, and a majority of typists all decided to change simultaneously, we are stuck with the QWERTY system. An informal version of the model of contingent-necessity is what might be called the QWERTY Principle: *Historical events that come together in an unplanned way create inevitable historical outcomes.*

V. BEYOND CHAOS: SELF-ORGANIZATION, ANTICHAOS, SIMPLEXITY, AND FEEDBACK

Sensitive dependency and bifurcations are only two aspects of chaos. "The straw that broke the camel's back" provides another metaphor of nonlinear dynamics. As the straw is piled on piece by piece, the camel's legs do not slowly bend lower and lower; rather, the camel maintains its straight-up stature until a critical breaking point is reached that causes the legs suddenly to collapse. Such is the nature of earthquakes, avalanches, economic depressions, ecological disasters, and quite possibly wars, revolutions, paradigm shifts, and other catastrophic historical events. Per Bak and Kan Chen describe this phenomenon as *self-organized criticality*, where "many composite systems naturally evolve to a critical state in which a minor event starts a chain reaction that can affect any number of elements in the system." They note that large systems such as geological plates, the stock market, and ecosystems "can break down not only under the force of a mighty blow but also at the drop of a pin." This one-pin-too-many, when dropped into a system in a critical or delicately balanced state, starts "a chain reaction that can lead to a catastrophe." Calling self-organized criticality a holistic theory, Bak and Chen claim that "global features of the system cannot be understood by analyzing the parts separately. To our knowl-
edge, self-organized criticality is the only model or mathematical description that has led to a holistic theory for dynamic systems."49

An instance of critically-induced catastrophe is a pile of sand in which single grains are dropped onto a flat, circular surface. The pile grows slowly and gradually into a gentle slope, and can be described by linear mathematics. But, "now and then, when the slope becomes too steep somewhere on the pile, the grains slide down, causing a small avalanche."50 This avalanche, or catastrophe, is triggered not by a major event or necessitating force, but by a minor contingency. (The avalanche, of course, could be triggered by a major event, but not necessarily.) The point at which the avalanche occurs Bak and Chen call chaotic. As the pile grows larger and larger, it "evolves on the border of chaos. This behavior, called weak chaos, is a result of self-organized criticality."51 Because the actions and locations of the early falling grains affect the actions and locations of later falling grains, "the dynamics of a system are strongly influenced by past events."52 In other words, history determines the system.

This action is what the model of contingent-necessity and its corollaries predict. The fall of the grains will be chaotic in the early stages and more ordered in the later, until reaching a certain point when a single grain can cause the whole system to collapse and start again. Contingencies (small grains of sand) construct necessities (large piles of sand), which grow to a point of criticality such that one more contingency can trigger a sudden and chaotic change. The model and its corollaries (particularly Corollary 5), itself a holistic theory for dynamical systems, explain where and when certain grains make a significant difference while others do not.

Stuart Kauffman has examined the greatest organizing principle in all of biology—evolution—and argues that the large-scale origins and development of life may have come about naturally as a result of what he calls antichaos. Noting that chaos theory explains the randomizing force that causes systems to become disorderly, Kauffman reverses the theory and argues that "There is also a counterintuitive phenomenon that might be called antichaos: some very disordered systems spontaneously 'crystallize' into a high degree of order."53 In the human genome, for example, out of the approximately 100,000 genes that code for the structure and function of a human body and brain, order naturally develops in the construction of approximately 100 different cell types. Likewise for the evolution of life itself. "Organisms might have certain properties not because of selection but because of the self-organizing properties of those systems on which the selection works."54 This emergence from chaos to order is described by Corollaries 1 and 4 and is a normal function found in many physical, biological, and social phenomena.

50. Ibid., 47.
51. Ibid., 52.
52. Ibid., 48.
54. Ibid.
What Kauffman calls antichaos Cohen and Stewart call *simplicity*, or "the emergence of large-scale simplicities as a direct consequences of rules," or laws of nature.55 These predictable laws interact with unpredictable contingencies to occasionally trigger the "collapse of chaos." After the collapse simple rules "emerge from underlying disorder and complexity," again as described in Corollaries 1 and 4. The antonym of Cohen's and Stewart's simplicity is *complicity*, "the tendency of interacting systems to coevolve in a manner that changes both, leading to a growth of complexity from simple beginnings — complexity that is unpredictable in detail, but whose general course is comprehensible and foreseeable."56 Complicity is a restatement of the model of contingent-necessity, especially Corollary 3.

Calling their work the first post-chaos, post-complexity analysis, Cohen and Stewart argue that where chaos theory shows that simple causes can produce complex effects, and complexity theory reveals that complex causes can produce simple effects, they demonstrate that simplicity is generated from the interaction of chaos and complexity: "We argue that simplicities of form, function, or behavior emerge from complexities on lower levels because of the action of external constraints."57 This is not unlike a conjuncture of events compelling a certain course of action by constraining prior conditions, or contingent-necessity.

To prove that human history also exhibits properties of complexity, antichaos, self-organization, and feedback mechanisms, note that certain historical phenomena repeat themselves, not in specifics but in universals. The witch crazes of the sixteenth and seventeenth centuries are iterated by many modern New Age social movements, specifically: mass hysterias, moral panics, alien abduction claims, fear of Satanic cults, and the latest craze—repressed memory syndrome. The parallels of these social movements to the witch crazes are too close to be accidental. Components of the witch craze movement are still alive in these modern descendants:

1. Women are usually the victims.
2. Sex or sexual abuse is almost always involved.
3. The mere accusation of potential perpetrators makes them guilty.
4. Denial of guilt is further "proof" of guilt.
5. Once victimization becomes well-known in a community, others suddenly appear with similar claims.
6. The movement hits a critical peak of accusation where almost anyone can be a potential suspect and no one is above reproach.
7. The pendulum swings the other way as the innocent begin to fight back against their accusers and skeptics demonstrate the falsity of the claims.
8. Finally the movement begins to fade, the public loses interest, and proponents are shifted to the margins of belief.

56. Ibid., 3.
57. Ibid., 2–3.
Why, we might ask, should there be such movements in the first place, and what drives these seemingly dissimilar systems in such a parallel manner? Stew-
art's self-organization and complexity explains how disordered systems become more and more complex until they reach a critical point upon which there is a dramatic change. Bak and Chen's self-organized criticality shows that at that point when the system is in a critically balanced state, any stimulus may trigger a catastrophe. Not to be outdone in neologisms, John Casti calls this interactive process complexification, expressed by the interaction of two systems, such as an investor with the stock exchange, or with more general "feedback/feedforward loops" in the economy.\textsuperscript{58} Feedback systems are those whose outputs are con-
nected to their inputs in such a manner that there is constant change in response to both, much like microphone feedback in a P.A. system, or heartrate moni-
toring in a biofeedback system. The rate of information exchange is the mecha-
nism that fuels the feedback loop and drives growth to the point of criticality (for example, stock prices go up and down in response to normal buying and selling, booms and busts are driven by a flurry of buying or selling when the system reaches criticality).

Social movements self-organize, grow, reach a peak, and then collapse, all described by Corollaries 1–5. To be more descriptive, to the model of contingent-
necessity I shall add Corollary 6: Between origin and bifurcation, sequences self-
organize through the interaction of contingencies and necessities in a feedback loop driven by the rate of information exchange.

In all these social movements, from the witch crazes of centuries past to the New Age claims of today, one can find these nonlinear patterns. The witch
crazes are repeating themselves in these modern descendants because of the similarity of the internal components of the systems and parallel social condi-
tions such as socioeconomic stresses, cultural and political crises, religious and moral upheavals, the social control of one group of people by another in power, and a feeling of loss of personal control and responsibility such that an enemy is needed to blame. So it was for the witch crazes in England and New England, triggered by the social stresses of the sixteenth and seventeenth centuries. So it is for these New Age movements today, following sharply on the heels of the turbulent 1960s, the a-religious and amoral 1980s, and the egalitarian and victimized 1990s.

These disordered social systems self-organize when a few claims are communi-
icated to the society at large primarily through the oral tradition (in the sixteenth century) and the mass media (today). The feedback loop is then in place. A woman is accused of being a witch and is publicly burned. News of the event spreads by word-of-mouth. (A woman in therapy "remembers" being abused and accuses her father. Her story is published in a few journals and small newspapers.) Suddenly other women in the community are similarly accused and burned. Neighboring communities hear about it and begin their own purge.

\textsuperscript{58} Casti, 262–263.
(Suddenly other women who read these stories of abuse start therapy and recall their own repressed memories.) The system is now growing more complex. As the rate of information exchange increases, the positive feedback loop grows and the event snowballs into a full-blown social movement. Witches are held responsible for all of the community's woes and are accused, tried, and burned en masse. (Repressed memory is the subject of all the talk shows, magazine programs, tabloids, major newspapers, and self-help books. Women are accusing their alleged assailants en masse.) Figure 1 shows the growth and collapse of the witch craze sequence from 1560 to 1620. Figure 2 shows what drives the sequence from self-organization to criticality—the rate of information exchange in a feedback loop between suspected witches and their accusers (top) and between villages (bottom).\textsuperscript{59}

Figure 3 documents the number of accusations of sexual abuse against parents, officially registered by the False Memory Syndrome Foundation, from almost nothing in 1992 to almost 12,000 cases in 1994.\textsuperscript{60}

The movement grows in complexity to a level of criticality, whereupon it collapses. Hundreds of thousands of women were killed and in some villages significant portions of the population were depleted until the psycho-socio-economic pressures were relieved and the witch craze collapsed. As for the

\textsuperscript{60} Data from False Memory Syndrome Foundation (Philadelphia) Newsletter, March, 1994.
Accusations of witchcraft in Manningtree, 1645.
(Suspected witches are in the central boxes; the arrows indicate accusations.)

Figure 2
The driving force behind the sequence from self-organization to criticality in the witch crazes of the sixteenth and seventeenth centuries—the rate of information exchange in a feedback loop between suspected witches and their accusers (top) and between villages (bottom).

Repressed Memory movement, it remains to be seen but observers at the False Memory Syndrome Foundation believe the movement is at or near its peak and will begin to decline, triggered by a number of factors, including: a successful settlement by Laura Pasley against her therapist, which has led to dozens of lawsuits filed against therapists; Gary Ramona's successful lawsuit and $500,000 award against his daughter's two therapists, opening the door to other third-
party lawsuits; the plethora of "retractors"—in the past six months over 300 women have retracted their original accusations; and perhaps most importantly in the reversal of the feedback loop, major media coverage now given to "False Memory Syndrome" rather than "Repressed Memory Syndrome."61

Alien abduction stories also nicely follow this sequence. Driven socially by Cold War anxieties and the burgeoning science fiction industry, alien abduction claims took off in 1975 immediately after millions watched NBC's portrayal of Betty Hill's abduction dreams as reality in The UFO Incident. The stereotypical alien with a large bald head and big elongated eyes, reported by so many abductees since 1975, was actually created by NBC artists for the show. The rate of information exchange accelerated as more and more abductions were reported in the news. As there seemed to be corroboration on the physical appearance of the aliens, as well as the sexual content of the experiences (usually women being sexually molested by the aliens), the feedback loop was established. The sequence recently received a boost from academia when Harvard psychiatrist John Mack published his best-selling book Abduction, making the usual rounds of talk shows and, not surprisingly, causing an increase in abduction claims.62

Another splendid example of mass hysteria is the strange case of the "phantom anesthetist" of Mattoon, Illinois, during the month of September, 1944. On September 1 a woman claimed that a stranger entered her bedroom and anesthe-

61. Ibid.
tized her legs with a spray gas. The Mattoon *Daily Journal-Gazette* ran the headline “Anesthetic Prowler on Loose.” Soon cases were reported all over Mattoon, the state police were brought in, husbands stood guard with loaded guns, and dozens of reports of eyewitness sightings were made. After ten days, however, no one was caught, no chemical clues were discovered, the police spoke of wild “imaginations,” and the newspapers began to report the story as a case of “mass hysteria.” With this the movement reached criticality, the feedback loop reversed, and the last attack was reported on September 12. As described in Corollary 6, the sequence had self-organized, reached complex criticality, switched from a positive to a negative feedback loop, and collapsed all in the span of two weeks.  

VI: THE PASTEBOARD MASKS OF LAPLACE’S DEMON

In 1814 the French mathematician Pierre Simon de Laplace published his *Essai Philosophique* in which he created the ultimate thought experiment:

Let us imagine an Intelligence who would know at a given instant of time all forces acting in nature and the position of all things of which the world consists; let us assume, further, that this Intelligence would be capable of subjecting all these data to mathematical analysis. Then it could derive a result that would embrace in one and the same formula the motion of the largest bodies in the universe and of the lightest atoms.
Nothing would be uncertain for this Intelligence. The past and the future would be present to its eyes.\textsuperscript{54}

Laplace's demon created a Satanic scare that set the science of nonlinear dynamics back a century and a half. It was a chimera. The demon did not exist. But physicists chased the dream, and historians chased the physicists. Then the physicists created a new language, and historians learned to decipher the words. But the words spoke an ancient language already known by the historians, and through a chaotic fog the physicists could hear Clio, the muse of history ask Urania, the muse of astronomy: Is not the apparent chaos of history the fog through which we squint to make out a faint outline of meaning to chart our course from the past to the future? Is not the mystery of our past like the whiteness of Ahab's whale, possessing us to "chase him round Good Hope, and round the horn, and round the Norway Maelstrom, and round perdition's flames before I give him up?" Only in the pursuit of this hue "can we thus hope to light upon some chance clue to conduct us to the hidden cause we seek." How do we get to this hidden cause? Herman Melville seems to be telling us, through Captain Ahab's obsessive quest for "that accursed white whale that razeed me; made a poor pegging lubber of me for ever a day," that we must unmask the demon and penetrate the outer layers, no matter how obfuscating, with every tool available:

All visible objects, man, are but as pasteboard masks. But in each event—in the living act, the undoubted deed—there, some unknown but still reasoning thing puts forth the mouldings of its features from behind the unreasoning mask. If man will strike, strike through the mask! How can the prisoner reach outside except by thrusting through the wall? To me, the white whale is that wall, shoved near to me. Sometimes I think there's naught beyond. But 'tis enough. He tasks me; he heaps me; I see in him outrageous strength, with an inscrutable malice sinewing it. That inscrutable thing is chiefly what I hate; and be the white whale agent, or be the white whale principal, I will wreak that hate upon him.\textsuperscript{65}

Read history for whale and facts for masks.

\textit{Occidental College}

\textsuperscript{54} Quoted in Philip Frank, \textit{Philosophy of Science: The Link Between Science and Philosophy} (New Jersey, 1957).

\textsuperscript{65} Herman Melville, \textit{Moby Dick} (New York, 1964), 135–136.