Winter Before Autumn
Self-Organized Criticality and the Black Death

This paper sets forth the conjecture that late medieval society by about 1300 was a self-organized system that approached, or had achieved, a state of criticality that persisted until at least the end of the fifteenth century. Fundamental attributes of self-organized criticality account for the resilience[1] shown by late-medieval society at the time and in the aftermath of the horrific experience of the Black Death.

Self-organized criticality is an emergent feature of systems composed of agents capable of complex behavior. These agents can be people, machines, or grains of sand, functioning in systems that look like societies, networks, or sand piles. The sand pile is the canonical self-organized system. As a grain of sand, multifaceted and of roughly uniform size, is dropped one at a time to create a pile of sand, the slope of the pile is formed. Below a critical threshold value for the slope, a grain of sand dropped on the pile dislodges at most a few neighboring grains in a tiny avalanche that never exceeds a very small number of grains. At or above the critical threshold value for the slope, a grain of sand dropped on the pile dislodges an unpredictable number of neighboring grains, producing an avalanche of unpredictable size. Any given single impact of a grain of sand can produce a barely noticeable ripple in the sand pile, or it can produce a

[1] David Herlihy, *The Black Death and the Transformation of the West* (Cambridge: Harvard University Press, 1997), 51. “The Black Death devastated society, but it did not cripple human resilience.” Nancy Siraisi, “Introduction,” in *The Black Death: the Impact of the Fourteenth-Century Plague, Papers of the Eleventh Annual Conference of the Center for Medieval and Early Renaissance Studies*, ed. Daniel Williman, (Binghampton: Center for Medieval and Early Renaissance Studies State University of New York at Binghampton, 1982), 19. “The current consensus seems to be that the massive plague outbreak of the fourteenth century no doubt accelerated existing social, economic, and cultural trends, but neither created nor radically changed them; and that the apparent ability of late-medieval society to adapt to and absorb such a major catastrophe without collapse is a remarkable tribute to the resilience of the culture.”

catastrophic landslide, or any cascading interaction in between. The threshold value for the slope is the boundary of criticality for the self-organized system that is the sand pile.[2] The general numerical signature of evidence of self-organized criticality is that the system's quantitative data can in principle be mapped into a straight line on a logarithmic scale. This quantitative evidence is typically found in phenomena that can be graphed by power law distributions, in behaviors that generate distinctive fluctuations of various rates and sizes, in objects that exhibit fractal geometry, and particularly in systems that can be said to undergo catastrophic changes. The evolutionary biological concept of punctuated equilibrium is an application of a catastrophic process in a critical self-organized system.[3]

Self-organized criticality also possesses two qualitative attributes by which its presence can be asserted. The first is linked to its quantitative aspects listed above, and the second is an unexpected counter-intuitive consequence of the first. The first attribute of a critical self-organized system is that it will experience avalanches of all sizes. The second attribute, discovered in studies of economic and traffic-bearing systems, is that "the critical state is the most efficient state *that can actually be reached dynamically*."[4] This is an extremely challenging notion for self-organized systems composed of human agents and entities, such as markets and societies, for it implies that a self-organized system cannot be managed or guided to a more efficient state than the critical state

[2] Per Bak, *How Nature Works* (New York: Copernicus Springer-Verlag, 1996), 32.
[3] *Ibid.,* 1-33. For example, Benoit Mandelbrot showed in 1963 that the monthly variations of cotton prices during a period of 30 months generated a fluctuating (1/f) signal of smooth transitions from small to large variations. When mapped into a logarithmic scale of the number of months where the relative variation exceeded a given fraction, this curve is for the most part a straight line of slope approximately –1 (Figure 3, pp. 15). This can be taken as conclusive evidence that the cotton market is a self-organized system. Similar numerical analysis of extinction events over the past 600 million years give strikingly similar results, showing that life on Earth is itself a self-organized system (Figures 4 and 5, pp. 16-17).
[4] *Ibid.,* 198. Bak's italics.

achieved through its own dynamic processes. The agents operating within the self-organized critical system are the best control possible for that system.[5]

In human societies that are critical self-organized systems - the civilization of the late Middle Ages was such a system - all manner of social, economic, medical, political, philosophical, theological, military, and cultural activities and developments comprise the historical processes that are the avalanche events. In the face of such complexity, this paper will seek to isolate a few components of late-medieval historical processes in order to show how the components, historical processes in themselves, may have affected or been changed by the larger process. To simplify this effort, component historical processes are examined and estimated to be processes of order or processes of disorder. Processes of order are those which, on the whole, dampen or absorb the effects of an avalanche of any size in the system; processes of disorder are those which, seemingly, amplify or promote the effects of an avalanche of any size in the system. A large avalanche is not necessarily a bad thing, nor is a small avalanche necessarily a good thing; either must be considered in the context of the historical process in which it occurs. Signs of processes of order are taken to be an indication of a step away from the boundary of criticality. Evidence of processes of disorder is taken to indicate the approach or presence of criticality.

Quantitative evidence of self-organized criticality in the pre-scientific society of the late Middle Ages is hard to come by, since its contemporary compilation is completely accidental. It is probable that much source data in the form of manor tax rolls and other still extant contemporary records remains to be uncovered and analyzed, at

[5] *Ibid.,* 198. “Maybe Greenspan and Marx are wrong,” observed Bak in 1996.

least in England. In the pronounced absence of sufficiently detailed numerical data from which the signature of criticality could be demonstrated or denied,[6] the narrative history of the era of the Black Death chiefly in England and France will be surveyed for clues to the presence of processes of order and disorder. Where the latter seem to dominate conditions, the potential exists for the first qualitative attribute of self-organized criticality to be manifest. The focus will be on cultural developments to show how the second qualitative attribute was operational during the historical process we now know as the Black Death.

The fractal nature of self-organized systems arising throughout history quickly becomes apparent. In late-medieval society, the Crusades, the Black Death, and the discovery of the New World are very large-scale historical processes composed of many avalanche events that are significant historical processes in their own right. Population growth and agricultural expansion are sizable avalanches with many beneficial effects stemming from the Crusades that rendered the thirteenth century prosperous and innovative. The discovery of the New World in the fifteenth century spawned incalculable avalanches of exploration and expansion.[7]

In 1959 Raymond Delatouche described conditions at the dawn of the fourteenth century. "Following the expansion of the tenth through the twelfth centuries, and after the balanced blossoming of the thirteenth century, there opened a period of intellectual doubt, social strife, and economic contraction…. From the end of the thirteenth century,

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[6] *Ibid.,* 100-107. Tests of such data as there is were not satisfactory for use here, on the grounds that the data lacked sufficient detail and documentation.
[7] Walter Prescott Webb, *The Great Frontier* (Austin: University of Texas Press, 1964; Lincoln: University of Nebraska Press, 1986).

technical innovation ceased."[8] Looking for the cause, Delatouche suggested that "two major events stand out: the Great Plague of 1348-1350 and the Hundred Years' War."[9] These events are prominent on the list of fourteenth century avalanches. There are at least two others.[10] Famine struck England in the early fourteenth century, when "the evidence of the years, 1310-19, shows a halt in population increase and the loss of perhaps a few per cent."[11] In England at the end of the fourteenth century, the War of the Roses was a "seemingly interminable civil war"[12] that led to the English loss of Bordeaux in the fifteenth century. Processes of disorder dominated the fourteenth century. Criticality was at hand. Which avalanche was the largest? The famine of 1317 that preceded the arrival of the Black Death by thirty years was a modest avalanche, yet by itself "hardly marks a turning point"[13] in population growth during the first half of the fourteenth century. The Hundred Years' War, "the work of man" which began a decade after the first visitation of plague to Europe, was a "lamentable situation that progressively enveloped France, …instead of a period of peace and calm in which the damage [of the plague] might have been repaired, there followed, particularly in France, a long chain of violence, destruction, and pillage."[14] Philippa Tristam recounted that "death in civil war is allowed no heroism. Like the plague, the Wars of the Roses are

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[8] Raymond Delatouche, "European Crises: The Plague or Moral Decline?" in *The Black Death: A Turning Point in History?* ed. William Bowsky (New York: Holt, Rinehart and Winston, 1971), 47, 53.
[9] *Ibid.*, 47.
[10] Climate change in the form of the "Little Ice Age" will not be included here, for brevity.
[11] Josiah C. Russell, "England: Preplague Population and Prosperity" in *The Black Death: A Turning Point in History?* ed. William Bowsky, (New York: Holt, Rinehart and Winston, 1971), 101.
[12] Norman Cantor, *In the Wake of the Plague* (New York: Free Press, 2001; New York, Perennial, 2002), 57.
[13] Russell, 102.
[14] Delatouche, 47.

seen as a punishment for the corruption of the times."[15] War and famine are all-too-familiar, recurring processes of disorder, fostering cascades of colliding events and actions that are often the greatest avalanches of their era, but in the fourteenth century, "Only the Black Death of 1348, because of its extent, severity, and suddenness can be characterized as a decisive disaster."[16]

What did the self-organized criticality of the fourteenth century look like? Critical self-organized systems have common theoretical attributes, but every system, market, ecology, network, era, or society will be different in appearance, nuance, and character. "What is striking, from the end of the thirteenth century," Delatouche conjured with continental insight, "is the collapse of moral potential, the loss of creative elan, the pursuit of leisure, even when leisure-time activities were of the highest quality – artistic, intellectual, and even religious. …On examining the situation more closely … one perceives that the plague did not strike a completely healthy body, but a weakened organism which had been manifesting signs of trouble and disequilibrium for decades."[17] Writing in the early 1960s, George Holmes saw the refraction in the larger historical process caused by the massive avalanche of the pestilence. "The Black Death of 1349 [sic] … initiated a long period in which the basic material forces working on society were different from what they had been in the central Middle Ages, and the change had profound effects on almost every aspect of history in the century after." Gazing across

[15] Phillipa Tristam, *Figures of Life and Death in Medieval English Literature* (New York: New York University Press, 1976), 11.
[16] Delatouche, 48.
[17] *Ibid*., 49, 48.

the Channel, Holmes elaborated. "The age of plague began quite suddenly with the Black Death and it quickly altered the climate and tendencies of English history."[18]

Beyond disequilibrium, this was a genuine excursion into catastrophe. To paraphrase Cantor[19], the historians of the twentieth century understood that extreme history had indeed impinged on conventional historiography.[20] The common consciousness of fourteenth-century contemporaries recognized instantly that something unique, horrendous, and inexplicable had occurred.

Before late twentieth-century research into the nature of complex dynamic systems, perhaps the noblest effort to define the Black Death historical process of the fourteenth century involved the invocation of the nineteenth-century ideas of Thomas Malthus. Malthus observed that populations grow geometrically while resources grow arithmetically, eventually precipitating a population crisis that must be resolved by a reduction in population. The Malthusian algorithm can be seen as a self-organizing process. In 1950 Michael Postan proposed that the demographic impacts of the Black Death could be understood with reference to "the inherent tendencies of populations of the Malthusian level of existence." Long before the advent of complexity theory, Postan offered this hypothesis "in order to underline the complexity of historical causation."[21]

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[18] George A. Holmes, "England: A Decisive Turning Point" in *The Black Death: A Turning Point in History?* ed. William Bowsky (New York: Holt, Rinehart and Winston, 1971), 91.
[19] Cantor, 183.
[20] Nancy Siraisi, "Introduction," in *The Black Death: the Impact of the Fourteenth-Century Plague, Papers of the Eleventh Annual Conference of the Center for Medieval and Early Renaissance Studies*, ed. Daniel Williman, (Binghampton: Center for Medieval and Early Renaissance Studies State University of New York at Binghampton, 1982), 10. "Despite the copiousness of the historical literature on the Black Death…the overall impact on society of that dreadful visitation remains curiously ill-defined."
[21] Michael M. Postan, "Malthusian Pressure and Population Decline," in *The Black Death: A Turning Point in History?* ed. William Bowsky (New York: Holt, Rinehart and Winston, 1971), 58.

David Herlihy in 1967[22] agreed that "the Malthusian diagnosis of the late-medieval crisis finds order and relationship among [the known facts]" but asked more concisely whether the events of the fourteenth-century represented "a true historical example of a classical Malthusian crisis?" Herlihy expressed a serious reservation with Postan's hypothesis, specifically because "the plague of 1348 did not strike against a population blindly seeking to increase." Although he believed that agricultural pressures were involved, Josiah Russell concurred with Herlihy so far as England was concerned, "It is clear that a plateau of population was reached in England before the Black Death."[23] Later, Herlihy described conditions in the fourteenth century as "not a Malthusian reckoning or crisis, but a deadlock." Without the semantic tools of complex self-organized systems, but persuaded that some state of affairs disposed to radical change prevailed, Herlihy suggested that "it is likely that this equilibrium could have been maintained for the indefinite future. … Then the plague struck. … It broke the Malthusian deadlock."[24] There was no deadlock to break. The slope of the fourteenth century was far beyond the threshold for criticality. The next grain of sand to drop was saturated with plague bacilli.

"The contrast between the extensiveness of the phenomenon and the poverty of the sources directly concerning it … is part of the history of the plague."[25] People and their culture survived the catastrophe and late-medieval civilization did not collapse. How, and why? "These two essential phenomena – the brutal, constant diminution in the

[22] David Herlihy, "Malthus Denied," in *The Black Death: A Turning Point in History?* ed. William Bowsky (New York: Holt, Rinehart and Winston, 1971), 61. Herlihy preferred an explanation based on low fertility.
[23] Russell, 103.
[24] David Herlihy, *The Black Death and the Transformation of the West*, 38. Self-organized criticality is far from "equilibrium." Often historians use the term when they mean *a bounded system.*
[25] Elisabeth Carpentier, "Orvieto: Institutional Stability and Moral Change" in *The Black Death: A Turning Point in History?* ed. William Bowsky, (New York: Holt, Rinehart and Winston, 1971), 113.

number of the living and the permanent menace that threatened them – profoundly affected the population and had important psychological consequences."[26] David Herlihy wisely advised "consider how plague affected the religious sensibilities of the Middle Ages … in the beliefs and practices of the people."[27] The agents capable of complex behavior in the critical self-organized system under discussion are the people of the fourteenth century. To ask what they believed and practiced is to ask what was in their minds, where "we meet … on the religious and psychological plane, the opposition between the apparent immutability of general structures and the profound trouble of individuals and souls."[28]

How did the late-medieval mind see the world? "Symbolism was very nearly the life's breath of medieval thought," Johan Huizinga wrote in 1919. "The ethical value of symbolic thought is inseparable from its formative value. … They never forgot that everything would be absurd if it exhausted its meaning in its immediate function and form of manifestation, and that all things extend in an important way into the world beyond."[29]

A powerful actualizing symbol was "the medieval obsession with death."[30] Huizinga commented on how strong death iconography related to cultural life. "The depiction of death may serve as an example of late-medieval thought in general, which frequently moves living thought from the abstract in the direction of the pictorial as if the

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[26] *Ibid.*, 112.
[27] David Herlihy, *The Black Death and the Transformation of the West*, 73.
[28] Carpentier, 112.
[29] Johan Huizinga, *The Autumn of the Middle Ages*, translated by Rodney J. Payton and Ulrich Mammitzsch. (Chicago: University of Chicago Press, 1996), 249, 240, 235. None of the words, "plague," "pestilence," or "Black Death," appear in the index of Huizinga's book.
[30] Tristam, 182.

whole of intellectual life sought concrete expression."[31] The psychological connection between religion and culture was profound. "There is an unlimited desire to bestow form on everything that is sacred, to give any religious idea a material shape so that it exists in the mind like a crisply printed picture."[32] Meaning, of things and of life, was thus substantiated by images. The grim subject was an important part of the epistemological method.

> Yf no nyght ne were, no man, as ich leyve,
>
> Shold wite witerly what day were to mene.[33]

Philippa Tristam found that "the figures of Life and Death…urge the necessity of darker understandings to a full comprehension of the meaning of day."[34]

Huizinga discussed the three basic motifs in the "vision of death." First came the motif of passing glory and the perishability of life. There is no finer example of this motif in medieval literature than the refrain in Francois Villon's "Ballade des dames du temps jadis" ("Ballad of Bygone Ladies"):

> *Mais ou sont les neiges d'antan?*[35]

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[31] Huizinga, 173.
[32] *Ibid.*
[33] William Langland, *The Vision of William concerning Piers the Plowman*, ed. W.W. Skeat, 1886, quoted in Tristam, xiii. My translation: If no night there were, no man, as I live,/Should know for certain what day was to mean.
[34] Tristam, xiii.
[35] Francois Villon, *The Poems of Francois Villon,* translated by Galway Kinnell (New York: New American Library, 1965), 66. "But where are the snows of last year?"

The ideas of this motif were also "embodied in the *De contemptu mundi* treatises so popular in the eleventh and twelfth centuries."[36] Death iconography and the "medieval obsession with death" had begun well in advance of the arrival of the plague. Next came the motif of decomposition. Joseph Polzer prefaced his key contribution to the discussion of death iconography in 1982 with the remark, "An intensifying preoccupation with natural death and decay is evident in the later Middle Ages. This intensified concern can be considered a by-product of a remarkable late medieval prosperity."[37] Kathleen Cohen confirmed that the first and second motif had been operating in medieval religious thought for centuries. "In an effort to make men consider their salvation … eleventh- and twelfth-century moralists vilified man's living body, gave detailed and vivid descriptions of the decay of the body in death, stressed the transience of worldly beauty and power, and the inevitability of death for all men."[38] The third motif was the theme of "The Dance with Death." It was expressed in many renditions and variations of art, and possibly living theatre, as the *Legend of the Three Living and Three Dead* and the much more elaborate *Danse Macabre*, a multiple panel social commentary on death in art and verse. Polzer carefully considered several examples of the third motif. He said "the most impressive contemporary representation of Death's power is the fresco known as the *Triumph of Death* in the Campo Santo in Pisa."[39] Polzer then articulated his most profound insight. "The Pisan *Triumph of Death*, the most spectacular representation of

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[36] Kathleen Cohen, *Metamorphosis of a Death Symbol, the Transi Tomb in the Late Middle Ages and the Renaissance,* (Berkeley: University of California Press, 1973), 24.
[37] Joseph Polzer, "Aspects of Fourteenth-Century Iconography of Death and the Plague," in *The Black Death: the Impact of the Fourteenth-Century Plague, Papers of the Eleventh Annual Conference of the Center for Medieval and Early Renaissance Studies,* ed. Daniel Williman, (Binghampton: Center for Medieval and Early Renaissance Studies State University of New York at Binghampton, 1982), 126.
[38] Cohen, 24.
[39] Polzer, 108.

this subject matter from the Middle Ages or the Renaissance, has nothing to do with the plague, which it precedes by nearly two decades."[40] Philippa Tristam gracefully connected the second and third motifs in a way that shows how they may have operated in late-medieval culture. "They were haunted by images of physical corruption, but by animating and confronting these figures, they brought themselves face to face with their own fears, and learnt what they could from them."[41]

It is in the symbolic processes of this cultural milieu of death iconography the second attribute of self-organized criticality applies. Late-medieval society was doing the best it possibly could in the fourteenth century.[42] By 1348 the culture of the late Middle Ages had in its own way preconditioned many individuals in society for a stark encounter with mass death. The question is not what was the impact of the plague on culture, but rather what was the impact of culture on the plague. Religious thought melded with cultural expression to create and foster a powerful process of order in a dangerously disordered system: death iconography supplied the symbolic shock absorber late-medieval society needed to meet the impact and avalanche of the Black Death.

Pete Ahrens
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[40] *Ibid.,* 126.
[41] Tristam, 183.
[42] Bak, 198. "The self-organized critical state with all its fluctuations is not the best possible state, but it is the best state that is dynamically achievable."

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